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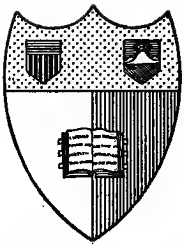

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MEMOIRS OF THE GEOLOGICAL SURVEY.
ENGLAND AND WALES.

EXPLANATION OF SHEET 154.

THE GEOLOGY
OF THE COUNTRY AROUND
LICHFIELD,

INCLUDING THE

NORTHERN PARTS OF THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE COALFIELDS.

BY

G. BARROW, W. GIBSON, D.Sc., T. C. CANTRILL, B.Sc.,
E. E. L. DIXON, B.Sc., AND C. H. CUNNINGTON, B.Sc.,

WITH CONTRIBUTIONS BY

J. B. HILL, R.N., T. EASTWOOD, A.R.C.Sc., AND J. PRINGLE.

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338. DARTMOOR...	—		1	6	2	3
339. NEWTON ABBOT... ...	—		1	6	3	0
341. WEST FLEET	—		1	6	10	6
342. PORTLAND and WEYMOUTH	—		1	6		
343. SWANAGE	—		1	6		
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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

EXPLANATION OF SHEET 154.

THE GEOLOGY

OF THE COUNTRY AROUND

LICHFIELD,

INCLUDING THE

NORTHERN PARTS OF THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE COALFIELDS.

BY

G. BARROW, W. GIBSON, D.Sc., T. C. CANTRILL, B.Sc.,
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PREFACE.

The area covered by Sheet 154 of the New Series one-inch map was originally surveyed by A. C. Ramsay, J. B. Jukes, E. Hull, and H. H. Howell, on the Old Series Sheet 62. The Old Series Sheet was published in four quarters, in the years 1852–56, with partial revisions extending up to 1886. The area included in it was described so far as regards the coalfields by J. B. Jukes in 'The Geology of the South Staffordshire Coalfield,' 1st Ed., 1853, 2nd Ed., 1859, and by H. H. Howell in 'The Geology of the Warwickshire Coalfield,' 1859. The Glacial deposits were not distinguished on the map, but were briefly referred to in the memoir on the South Staffordshire Coalfield.

The resurvey was made on the six-inch scale, under the superintendence of Mr. Barrow as District Geologist. Mr. Barrow himself surveyed the northern part of the Warwickshire Coalfield and much of the adjoining area on the north. The part of the South Staffordshire Coalfield which falls within Sheet 154 was surveyed by Dr. Gibson and Mr. Cantrill, and the area between the two coalfields by Mr. Barrow, Mr. Dixon, and Mr. Cunnington. The north-eastern part of the map was the work of Mr. J. B. Hill, and a small part in the south-east was that of Mr. T. Eastwood.

In the writing of this memoir Mr. Barrow has taken a prominent part, much of his spare time since his retirement from the staff having been devoted to the work. Among the more important subjects dealt with, mention may be made of the mapping of the highest subdivisions of the Carboniferous system, which had long been known to exist in the area described, as well as in North Staffordshire and elsewhere. The tracing of the outcrops of these groups of conglomerates sandstones, and marls marks an advance in the process of proving the productive measures concealed beneath them, inasmuch as it renders possible estimates of depth. From a purely scientific point of view also these strata are of much interest, especially in their assumption of littoral characters in certain districts. Near the inlier of Cambrian rocks at Dosthill for example, the Etruria Marls are composed locally of chips of Cambrian shale, evidently derived from a shore-line close by. The existing eminence at Dosthill, however, owes its form to post-Carboniferous and post-Triassic movements and to denudation which ensued upon them; it represents in a modified degree only such features as may have existed in Carboniferous times.

The Keele group, the highest subdivision of the Carboniferous system recognised in the Midlands, passes up into a mass of sandstones, marls and conglomerates aggregating upwards of 2,000 feet in thickness. These Hamstead Beds, as they have been named by Mr. Hardaker, have yielded a few plants and some reptilian footprints which he regards as indicative of a 'Lower Permian' age. On the other hand, their insensible gradation into the Keele beds below, and the fact that they are not only unconformably overlain by the Hopwas and Clent breccias above, but separated by a period of great earth-movement from the Permian (Magnesian Limestone) group of other parts of England, renders it difficult to remove them from the Carboniferous. They would appear to fill, more or less completely, a gap which occurs generally in the British sequence, and to form what is perhaps a unique record of the closing episodes of the Carboniferous period in this country.

At the base of the Trias, or at the base of the Hopwas Breccia where that bed is developed, there exists an unconformity of the first magnitude. These strata may rest upon any of the older formations, and though concealed coalfields certainly exist beneath parts of the areas occupied by them, the depth, situation and limits of such tracts are problematical. The Glacial deposits show evidence of derivation from two distinct sources, the one lying to the east and north-east and contributing debris of Jurassic rocks with chalk-flints, the other lying to the north-west and contributing boulders from North Wales, the Lake District and possibly Scotland.

Apart from the South Staffordshire Coalfield, much of the district is free from Glacial drift. A 'solid edition' of the one-inch map is therefore unnecessary.

In the course of the resurvey we have been indebted to a large number of mining engineers, colliery managers, and surveyors for unfailing courtesy in placing records at our disposal. Mr. Arthur Sopwith's long experience of the process of development of the northern part of the South Staffordshire coalfield enabled him to render assistance which calls for special acknowledgment.

A. Strahan,
Director.

Geological Survey Office,
28, Jermyn Street, London, S.W. 1.
7th June, 1918.

LIST OF SIX-INCH MAPS.

The following is a list of the six-inch Geological Maps included in the area. Manuscript coloured copies have been deposited for public reference in the Library of the Geological Survey and Museum of Practical Geology. Those which relate to the coalfields are marked with an asterisk.

STAFFORDSHIRE, WITH ALTERNATIVE NUMBERS RELATING TO DERBYSHIRE AND WARWICKSHIRE.

45, S.W.	Cannock Chase, by W. Gibson.
*45, S.E.	Rugeley, by T. C. Cantrill.
46, S.W.	Armitage, by E. E. L. Dixon.
46, S.E.	King's Bromley, by J. B. Hill.
47, S.W.	(=Derby 59, S.W.), Alrewas, by J. B. Hill.
47, S.E.	(=Derby 59, S.E.), Walton-upon-Trent, by J. B. Hill.
*51, N.W.	Hednesford, by W. Gibson.
*51, S.W.	Cannock Town, by W. Gibson.
*51, N.E.	Beaudesert, by T. C. Cantrill.
*51, S.E.	Chase Terrace, by T. C. Cantrill.
52, N.W.	Longdon Green, by E. E. L. Dixon.
52, N.E.	Elmhurst, by E. E. L. Dixon.
52, S.W.	Wall, by E. E. L. Dixon.
52, S.E.	Lichfield, by E. E. L. Dixon.
53, N.W.	(=Derby 62, N.W.), Croxall, by J B Hill.
53, S.W.	(=Derby 62, S W.), Elford, by C. H. Cunnington.
*57, N W.	Wyrley, by W. Gibson.
*57, S.W.	Bloxwich, by W. Gibson.
*57, N.E.	Chasetown, by T. C. Cantrill.
*57, S.E.	Walsall Wood, by T. C. Cantrill.
58, N.W.	Hammerwich, by E. E. L. Dixon.
58 N.E.	Whittington, by E. E. L. Dixon.
58, S.E.	Shenstone, by E. E. L. Dixon.
58, S W.	Stonnall, by C. H. Cunnington.
59, N.W.	(=Warwick 2, N.W.), Comberford, by G. Barrow, E. E L. Dixon and C. H. Cunnington.
*59, N.E.	(=Warwick 2, N.E.), Statfold, by G. Barrow and C. H. Cunnington.
59, S.W.	(=Warwick 2, S.W.), Hopwas, by G. Barrow.
*59, S.E.	(=Warwick 2, S.E), Tamworth, by G. Barrow.
*63, N.W.	Bentley, by W. Gibson.
*63, S.W	Darlaston, by W. Gibson.
*63, N.E.	Rushall, by T. C. Cantrill.
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64, S.W.	Sutton Park, by C. H. Cunnington.
64, S.E.	(=Warwick 4, S.E.), Sutton Coldfield, by C. H. Cunnington and T. Eastwood.
*65, N.W.	(=Warwick, 5, N.W.), Fazeley, by G. Barrow.
*65, N.E.	(=Warwick 5, N.E.), Wilnecote, by G Barrow.
*65, S.E.	(=Warwick 5, S.E.), Kingsbury, by G. Barrow.
65, S.W	(=Warwick 5, S.W.), Middleton, by T. Eastwood.

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Shaft Sections in the North Warwickshire Coalfield
at end of volume.

THE GEOLOGY

OF THE COUNTRY AROUND

LICHFIELD.

CHAPTER I.

INTRODUCTION.

By G. Barrow.

PHYSICAL FEATURES.

The district of which the geology is described in the following pages lies almost entirely within the Lichfield Sheet (154) of the New Series one-inch map, but it includes also a narrow strip outside the northern margin of the map, which has been surveyed in order to complete the six-inch maps. In addition some recent information is given bearing on the area to the east, in the New Series one-inch Sheet 155, of which the map and memoir were published in 1899 and 1900 respectively.

The whole of the area is drained by the Trent and the Tame with their tributaries (see Sketch Map, Fig. 1), more than half of it by the Tame. Rising near Walsall, this river flows southwards out of the map, but re-enters it on the eastern side much increased in volume and meandering in a wide alluvial flat. It joins the Trent in the north-eastern corner of the district, after having received several tributaries, of which the more important are the Bourne Brook on the west side and the Anker on the east.

The larger river, the Trent, flows through the north-eastern corner of the area and gathers tributaries from the ground between Lichfield and Cannock Chase. Both the Trent and the Tame are bordered by broad alluvial flats, but there is an appreciable difference in their rate of fall; the gradient of the Trent above its junction with the Tame is sufficiently steep to prevent extensive flooding, but that of the Tame is so low that large portions of the valley are overflowed, even in summer. The widest floods occur at and above Tamworth and not infrequently lead to the stoppage of roads. For the most part the slopes of the valley-sides are gentle, but on the eastern side of the Tame at Dosthill the Cambrian and associated igneous rocks rise abruptly from the edge of the Alluvium and form the steepest bank in the district. Occasionally in the course of their oscillations the rivers cut back into the slopes of the Keuper Marl, but the bluffs so formed are small. It is noticeable that such features are more common in the Trent valley, which has the faster fall.

Elevations of 450 ft. above the sea are reached to the east of the Tame, south of Tamworth, where the resistant Carboniferous

(5453.) Wt. 10083—30. 750. 10/19. J. T. & S., Ltd. G. 14. Sch. 11.

sandstones rise to the surface; but north of Tamworth, in the Keuper Marl area, only twice is an altitude of nearly 320 ft. attained, while the river-level is about 180 ft. above sea-level.

To the west of the Tame the ground gradually rises toward the South Staffordshire coalfield, which attains an average altitude of about 500 ft.; but about Cannock Chase, where the Coal Measures are overlain by the more resistant Pebble-Beds, it reaches about 780 ft. near the eastern escarpment of these rocks. The highest point in the district lies, however, on the drift-covered Coal Measures of Castle Ring, in Beaudesert Park, where an altitude of 801 ft. is attained.

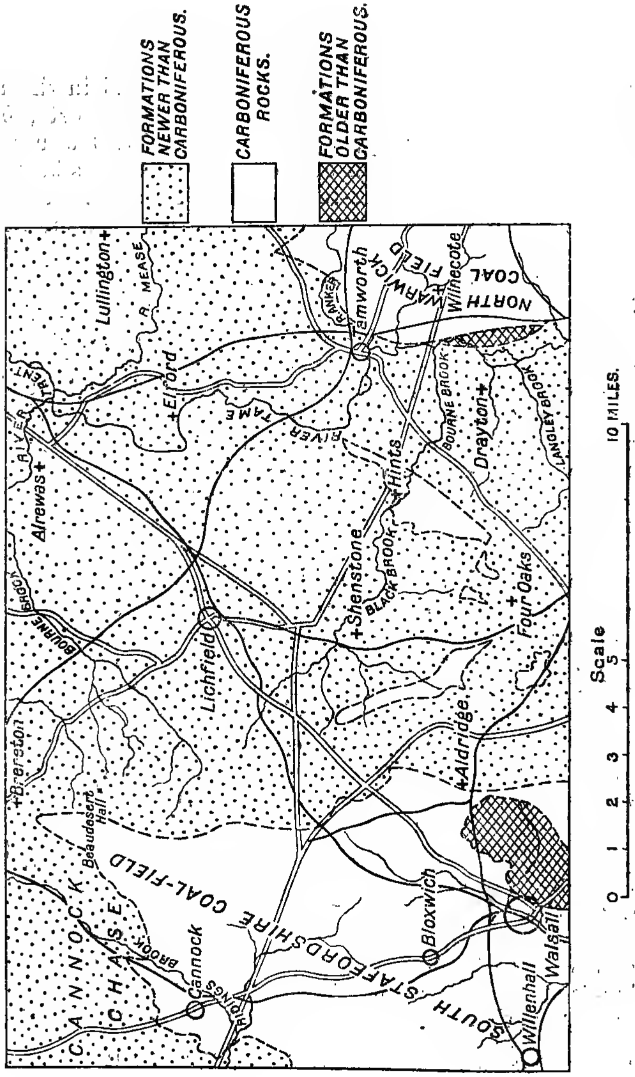

FIG. 1.—*Area of Sheet 154 (Lichfield).*

TABLE OF STRATA AND GEOLOGICAL STRUCTURE.

The following formations are represented on the map:—

Recent to Pleistocene	Recent		Peat. Alluvium.
	Post-Glacial		River Gravels.
	Late-Glacial ?		Older River Gravels.
	Glacial		Bedded Sand and Gravel and Unbedded Gravelly Drift passing locally into pebbly clay.
Trias	Keuper	Keuper Marl	Red marl with thin sandy bands.
		Keuper Sandstone (including Waterstones)	Mainly sandstone with some marl; upper part, thin sandstones and marl.
	Bunter	Upper Mottled Sandstone	Soft, loamy, fine-grained sandstone.
		Pebble-Beds	Rather coarse sandstone, with beds full of pebbles.
	LOCAL UNCONFORMITY.		
Permian ?	Hopwas Breccia		Soft red-brown sandstone; beds with subangular pebbles at top.
	GREAT UNCONFORMITY.		
Carboniferous ?			Hamstead Group. Red sandstones and marls with conglomerates.
Carboniferous	Upper Coal Measures		Keele Group. Red marls and sandstones, with occasional Spirorbis limestones.
			Halesowen Group. Grey marls with the Index Spirorbis Limestone, above; mainly sandstones in lower part.
			Etruria Marl Group. Red and mottled marls, with green grits (Espley Rocks).
	Middle Coal Measures		Clays and grey shales with thin sandstones and numerous coal-seams.
	GREAT UNCONFORMITY.		
Silurian	Lower Ludlow Shales		Shales.
	Wenlock Limestone		Limestones.
	Wenlock Shale		Shales.
	Woolhope Limestone		Limestone.
	GREAT UNCONFORMITY.		
Cambrian	Stockingford Shales		Buff and dark shales.
Igneous Rocks	Intrusive in Carboniferous		Basalts.
	Intrusive in Cambrian		Minverites.

The distribution of the more widespread geological formations is indicated on the accompanying sketch-map (Fig. 1), and brief notes on their leading characters and influence on the scenery may be given here. The oldest rocks visible at the surface consist of hard shales of Cambrian age, which crop out on the eastern bank of the Tame, three miles south of Tamworth. They rise sharply from the alluvial flat and though of small extent form a conspicuous hill, partly through their having been penetrated by a number of igneous rocks. They have contributed largely to the material of which the Coal Measures of their neighbourhood consist, and clearly formed a land-area in Coal Measure times. The

Silurian rocks, which consist of limestone, calcareous shale and mudstone, occupy several square miles near Walsall. All the subdivisions except the Upper Llandovery Sandstone are represented, up to the base of the Lower Ludlow. The Woolhope or Barr Limestone and the two beds of Wenlock Limestone have long been worked. Near Walsall the Silurian rocks lie directly below the Carboniferous, and their extension northwards in the same unconformable relation has been proved by borings.

No Carboniferous Limestone or Millstone Grit exists at the surface and all the overlying subdivisions of the Carboniferous formation are grouped together on the sketch-map under the head of Coal Measures. Among these are included, in ascending order, the productive grey or Middle Coal Measures, the Upper Coal Measures, and the Hamstead Group.

The Middle Coal Measures are poorly exposed in the northern part of the Warwickshire Coalfield and are mostly masked by Glacial deposits in that of South Staffordshire. In both coalfields the Upper Coal Measures are more clearly exhibited. The Keele Group is now usually placed in the Upper Coal Measures, but the age of the red beds with conglomerates (Hamstead Beds) into which the Keele Group graduates upwards is still under consideration. In the total absence of coal-seams it seems inadvisable to include these strata in the Coal Measures, but on the other hand, they are definitely separable from the Hopwas Breccia. Their chief outcrops occur between the two coalfields, but a narrow strip fringes the eastern side of the South Staffordshire Coalfield and gradually broadening southwards is continuous with the outcrop of the conglomeratic red beds to which the name of Hamstead Group has been given.[1]

Whether the Hopwas Breccia can be classed as Permian remains in doubt. It contains pebbles of limestone and subangular fragments of various rocks, which distinguish it from the overlying Bunter conglomerate, and, moreover, it was subjected to erosion before that conglomerate was deposited. On the other hand, it was distributed after the greater movements in the Carboniferous rocks had been completed, and as regards its outcrop associates itself more nearly with the Bunter than with the Carboniferous. Thus there are reasons against placing it in either, and it is classed provisionally as Permian. It occurs at the surface over a belt of ground stretching from the Four Oaks area, where it forms a fairly wide spread, north-eastward to Hints and Hopwas, where it appears in a number of isolated outcrops, and in a narrow band which continues almost to the Tame.

The Trias covers much of the area between the two coalfields. It includes, in ascending order, the Pebble-Beds and Upper Mottled Sandstone of the Bunter, the Keuper Sandstone, and the Keuper Marl. The Bunter is composed of somewhat coarse sandstones and contains a varying number of beds of well-rounded pebbles. The Keuper Sandstone is of finer grain and is associated with bands of marl. In all cases it graduates upward into the Keuper Marl. Scenery characteristic of the Bunter is displayed in Cannock Chase and in another large outcrop east of the South Staffordshire Coalfield. On the sketch-map (Fig. 1) the Upper Mottled Sandstone, a brightly-coloured rock devoid of pebbles, is included with the Pebble Beds. The Keuper Sandstone occupies a broad belt of ground about the centre of the map. The city of Lichfield stands on the northern part of the outcrop.

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[1] Hardaker, W. H., 'The Permian Rocks of Hamstead,' *Quart. Journ. Geol. Soc.*, vol. lxviii, 1912, p. 639.

The Keuper Marls extend from near Cannock Chase eastwards across the northern part of the map, but are partly obscured by gravel and alluvium. They also constitute nearly the whole of the ground between the Anker and the Tame, and beyond the latter continue in a broad belt stretching south-west far into the adjacent area to the south. The boundaries of the Glacial Deposits are too complicated to be shown on the map on p. 2.

River Gravels and Alluvium are widely distributed along the Trent near its junction with the Tame; alluvial deposits fringe the Tame and the Anker to the south, but are not indicated in Fig. 1.

Two features that catch the eye in this area of somewhat subdued relief are connected with faults. The first, to the west of Tamworth, is due to the Hints Fault, which brings up high Carboniferous rocks capped by Pebble Beds, the whole rising in a singularly straight bank above the Keuper Marl plain. The other feature referred to is formed by the escarpment of the Bunter Pebble-Beds on the eastern side of Cannock Chase. These Pebble-Beds form most of the more picturesque portions of the district. Cannock Chase has long been famous for its beauty and its timber, and the woods about Hints are almost as picturesque. The sylvan character is noticeable also about Shenstone and Weeford.

The main structure of the country is connected with large faults accompanying folding, along which movements have taken place during at least two different epochs. The two most important of these form respectively the eastern margin of the South Staffordshire Coalfield and the western margin of the Warwickshire Coalfield, and between these two lies a sunken area, mainly occupied by Triassic rocks. It must not be supposed, however, that the Trias was originally confined to the sunken area, for though the greater part of the faulting was completed before the Trias was deposited, subsequent faulting took place in post-Triassic times. This led to certain differences in the structure of the Trias and Carboniferous strata. Thus the Trias of the sunken area dips northwards, so that newer beds come on in that direction. On the other hand, the Carboniferous rocks beneath the Trias rise to the north, and the highest beds are present only in the south. The northerly dip of the Trias was probably due to or accompanied by the formation of the Hints Fault already referred to.

DISTRIBUTION OF THE POPULATION.

The distribution of the population is largely dependent on that of the Coal Measures, which yield the coal, clays, and formerly the ironstone required for the most important industries. Walsall, Willenhall, Bloxwich, Cannock and Cheslyn Hay are industrial centres in the South Staffordshire Coalfield, while Tamworth, with its suburb Glascote, forms a centre for the North

Warwickshire Coalfield; in both areas there are minor concentrations of population at the numerous colliery villages. A picturesque area about Streetly, Four Oaks, etc., situated near the centre of the southern edge of the map, is being rapidly built over and converted into a residential district. Lichfield forms the ecclesiastical and agricultural centre.

CHAPTER II.

PRE-CARBONIFEROUS FORMATIONS.

CAMBRIAN ROCKS.

By G. Barrow.

At Dosthill, two and a half miles south of Tamworth, Cambrian Shales form an inlier about one and a half miles long by about half a mile broad. They rise abruptly from the Tame Valley and overtop the surrounding area, chiefly through their having been hardened by igneous intrusions. The northern part of the inlier is encircled by Keuper Sandstone and Marls, which rest upon or have been banked against the shales, but on the south-western side the Trias is faulted against the shales. To the south-east the Coal Measures come into contact with the Cambrian Shales, but the nature of the junction is not clear. The dip of the coals rapidly increases to verticality as the Cambrian is approached, as though there were a break of some kind, yet in a small lane leading from the high road to the village of Dosthill, the lowest coal-seam is present, while all the others appear to come on in their natural order. There may be some overthrusting, but for the most part the Coal Measures appear to rest naturally on an eroded surface of the Cambrian shales (Fig. 5, p. 159).

When the first edition of the geological map of the Warwickshire Coalfield was published these shales, which occur on both sides of the field, were classed as Coal Measures, as after considerable discussion it was believed that they followed conformably below those rocks. But in 1882 Prof. Lapworth[1] announced his discovery of Cambrian fossils in similar shales near Atherstone. Following on this announcement Mr. W. J. Harrison[2] examined sections at Dosthill and concluded that the shales there exposed were of the same age as those of the neighbourhood of Atherstone.

In consequence of the discovery by Professor Lapworth the mapping of the pre-Carboniferous rocks on both margins of the coalfield was revised,[3] and a second edition of the map was published in which the name 'Stockingford Shales,' suggested by Mr. W. J. Harrison, was adopted, but the definition of Lower Silurian, after Murchison, was retained. When the re-survey of the eastern side of the coalfield was completed the modern nomenclature was adopted, and the Stockingford Shales are accordingly shown in the New Series map (Sheet 155) as Cambrian.

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[1] *Proc. Birmingham Phil. Soc.*, vol. iii, p. 234. Reprinted in *Geol. Mag.*, 1882, p. 563.

[2] *Geol. Mag.*, 1882, p. 565. *See also* 'Midland Naturalist,' vol. viii, 1885.

[3] 'On the Rocks surrounding the Warwickshire Coalfield, and on the base of he Coal-measures.' By A. Strahan, *Geol. Mag.*, 1886, pp. 540–557.

The Stockingford Shales have been divided into two parts, the lower consisting of purple, green and grey shales, the upper of barren buff and grey shales, with thin bands of much darker fossiliferous material. At Dosthill this upper part only is present and no fossils were found until, in cutting an approach to a quarry in one of the igneous rocks, a small part of the darker material was laid open; from this Mr. J. Pringle obtained *Hyolithes sp.*, *Acrotreta sagittalis* (Dav.) and a trilobite spine.[1] Recently the base of the igneous rock has been reached, and beneath it a considerable amount of hardened, but evenly-splitting black shale has been exposed to view, but no more fossils have been obtained.

The buff shales are composed of a fine sandy mud containing minute flakes of white mica. They include an abundance of small pellets or nodules, the nature of which is not easy to ascertain, as they are preserved only in rock which has been hardened by the igneous intrusions.

The shales referred to as having been found under igneous rock are almost jet-black, and greatly hardened; close to the intrusion they contain a considerable amount of easily visible pyrites. Microscopic sections (E. 11153-11160) made from specimens collected at or close to the junctions, are reported on by Dr. H. H. Thomas as follows:—

"One specimen (11153) in contact with the sill shows no obvious alteration. It is a finely-banded sediment, the bands being parallel to the margin of the sill. Possibly, however, some minute scales of chlorite may represent decomposed biotite of thermal origin. The rock is extremely fine-grained, and it is almost impossible to individualise any of the original clastic grains. There is a general appearance of slight silicification and a patchy development of ferruginous carbonates. In another (11156) the original structure of the shale appears to have been partly obliterated. Patches of chloritic matter are more obvious and certainly indicate the presence of some ferro-magnesian mineral, probably biotite. At the same time the evidence of contact alteration is inconclusive.

"The specimens taken about an inch from the junction (11154-11155) have the look of a finely-sheared sediment of a character similar to that described above They are rich in iron compounds, both sulphides and oxides, and have the same patchy development of carbonates. The concretionary patches of pyrite, though still minute, are largest in the second specimen. Neither shows signs of contact alteration. The faint spotting shown on the margins of most of the intrusions is rather better seen on the edge of this. Two specimens collected at the surface (11159-60) are fine-grained sediments which show minute spotting. The spots have a lower birefringence than the rest of the rock, which seems to consist largely of sericitic matter and minute clastic grains of other minerals. The character of the mineral forming the spots cannot be determined."

It is difficult to make out any definite structure in the area formed by these shales, for the dips vary both in direction and amount, probably through the disturbing effects of the intrusions. The specimens from below the igneous rock frequently show small sigmoid folds, suggestive of a considerable amount of disturbance, and in the entrance to the quarry several larger folds can be made out.

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[1] Registered Pl. 3762–3783.

That there must be a roughly north and south strike is suggested by the fact that though the outcrop is about a mile and a half long only the upper part of the shales is seen. One moderately large fault, seen in the tram-road leading down into the quarry, breaks through both shales and igneous rocks. The movement was certainly pre-Triassic, and may have been pre-Carboniferous. The intrusions are described on pp. 196, 197.

SILURIAN ROCKS.

By T. C. CANTRILL.

General Description.

In Sheet 154 is included only a part of the Silurian outcrop of the Walsall district, but with the exception of the Upper Llandovery it contains representatives of all the subdivisions up to the Lower Ludlow. The succession is as follows, in descending order:—

SILURIAN OF THE WALSALL DISTRICT.

		Ft.
Lower Ludlow Shales (part), proved underground up to		214
Wenlock or Dudley Limestone	Upper Thin, or Little Limestone, about	12
	Nodular Beds, 108½ ft. to	120
	Lower or Thick Limestone, 33 ft. to ...	36
Wenlock Shales, 500 ft. to...		600
Woolhope or Barr Limestone (part), up to		30
		1,012

The supposed Upper Llandovery of Daffodil Farm (Daffodilly on the Old Series one-inch map) has proved to be a Coal Measure Sandstone, and the base of the Barr Limestone is not exposed. The Barr Limestone has always been correlated with the Woolhope Limestone. Like that rock, it immediately underlies the Wenlock Shales, and presumably follows not far above the Upper Llandovery Sandstone, though the connexion between the two is nowhere seen in Sheet 154, while at Shustoke Lodge (Sheet 168) the junction is faulted. There is no reason to doubt, however, that if the full succession could be examined the Barr Limestone would be found to be separated from the Upper Llandovery Sandstone by a group of shales equivalent to the Ledbury Shales of Malvern and the Woolhope and Tarannon Shales elsewhere. The Barr Limestone resembles, in a general way, that of Woolhope in thickness, lithology, fauna and systematic position, and the quarries at Hay Head, near Walsall, were the first to yield the characteristic trilobite *Illaenus barriensis*,[1] subsequently found in other exposures of the Woolhope Limestone, though it ranges upward into the Wenlock Limestone.

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[1] First described by F. Jukes and J. de C. Sowerby in *Mag. Nat. Hist.*, vol. ii, 1829, p. 41.

The Wenlock Limestone of Walsall differs from that of the type-area of Shropshire in consisting of two distinct bands separated by a thick group of nodular calcareous shales.

The Woolhope and Wenlock Limestones in this district have been burnt for lime from an early period. The workings at Daw End (often spoken of as the Linley Works) may date even from Roman times; for Shaw in 1801 recorded that a Roman fibula and coins were found in 1795 during some excavations on Linley Farm, while an *Orthoceras* has been noted as occurring in the mortar of the walls of Etocetum (Wall, five miles north-east of Daw End). It is probable, therefore, that the Romans obtained lime from the Wenlock outcrops at Daw End or from the Barr Limestone farther east. References to limeworks in the Walsall district occur in a deed of 19 Ed. II (1325-6), and are scattered through the pages of the early topographers, *e.g.*, Leland (*c.* 1540), Plot (1686) and Shaw (vol. ii, 1801). But the first comprehensive description of this part of South Staffordshire is that by Murchison[1] in 1839, which was followed by that of J. Beete Jukes[2] in the Survey Memoirs published in 1853 and 1859.

Lithology.—The Barr Limestone consists of a group, at least 30 ft. thick, of alternating limestones and shales. The limestones vary from 3 to 9 in. in thickness, and are divided into flattened spheroids or brick-shaped nodules with rounded angles. They weather to a buff colour, but show a grey or light-blue core. The beds of nodules alternate with buff-weathering grey shales in bands 9 to 12 ins. thick. This description applies to the uppermost beds of the formation, which alone are now visible in the old quarries. Murchison records that the best limestone took the form of seven bands, totalling 7 ft. in thickness; by local tradition the thickness is given as 12 ft.

The Wenlock Shales, into which the Barr Limestone passes upward by the diminution of the number and thickness of the bands of limestone-nodules, are highly-calcareous grey shales, weathering at the surface to a buff colour. They contain numerous thin bands (less than a foot thick) of richly fossiliferous limestone, especially toward the top, while fossils are plentifully scattered throughout the shales themselves.

The Lower or Thick Limestone of the Wenlock is made up, in the Walsall district, of about 18 separate bands, varying in thickness from 3 in. to 5 ft., with an aggregate thickness of 33 to 36 ft. The following is the section[3] of the Lower Limestone as measured at the Phœnix Limeworks at Daw End:—

Lower Wenlock Limestone, Daw End.

Name of Bed.		Thickness.				
		Ft.	In.		Ft.	In.
Twenty-Inch	left for Roof	1	8		1	8
Fourteen-Inch		1	2		1	2
Thick Burr		4	6	to	5	0
Chatterer			8	to	1	0

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[1] 'Silurian System,' p. 488.

[2] 'S. Staff. Coalfield,' ed. 1, 1853, pp. 237, 268; ed. 2, 1859, pp. 106, 159.

[3] Communicated by Mr. John Brawn and Mr. Chas. W. Ellis.

Name of Bed.	Thickness. Ft.	In.		Ft.	In.
Chippers	3	0	to	3	3
Captain Batt		3			3
Captain		10	to	1	0
Seven-Floors	1	3		1	3
Fourth-Shot } Variable	1	3		1	3
Third-Shot }	1	0	to	1	2
Strong Stone	2	0	to	2	3
Bumming Measure		8	to		10
Dirt-parting		3			3
Flints	2	6	to	2	9
Bell Flag	1	0		1	0
Knotty-Floor	5	0		5	0
Thick-Floor	3	6	to	3	9
Rottens	2	6	to	3	0
Total thickness of limestone	33	0	to	35	10
Deduct roof, unworked	8	0	to	8	10
Thickness of limestone worked	25	0	to	27	0

These names are used throughout the district for the several bands, which, while varying somewhat in thickness, are recognizable in most of the workings. The average colour of the rock is grey, with a slight tendency to brown. Picked samples taken from the whole thickness of 36 ft. give 90 to 93 per cent. of $CaCO_3$.

The Nodular Beds consist of a mass of small calcareous nodules or concretions ('bavin' of the quarrymen) closely packed in an argillaceous matrix ('rotch'). On analysis the concretions and clay matrix taken together give 35 to 70 per cent. of $CaCO_3$.

The Upper, Thin or Little Limestone is flaggy, and the stone was used principally as a flux in the ironworks, but little information about it is now obtainable.

In the Wenlock Shales, the Lower Wenlock Limestone, and the Nodular Beds, large unstratified masses of coralline limestone, known as 'ballstones' or 'self-lumps,' are occasionally present. They are a common feature of the Wenlock Limestone at Wenlock, and appear to be masses of coral in position of growth.[1]

Palæontology.—The fauna of the Silurian rocks of the Walsall district is well-known, and is abundantly represented by specimens in most collections. In Jukes's Memoir[2] on the coalfield Salter gave an account of the palæontology, which requires little modification for our present purpose.

The Woolhope or Barr Limestone was formerly quarried from near Aldridge Lodge in the north, past Hay Head, the Three Crowns and Daffodil Farm, nearly to Daisy Bank, but the workings are largely overgrown. During the recent survey fossils have been collected from some of these old quarries and from other exposures, and are given in the following list, in which the numbers refer to the localities[1] at which each form was found:—

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[1] Murchison, 'Sil. Syst.', pp. 210–212, 484. Also M. C. Crosfield and M. S. Johnston, *Proc. Geol. Assoc.*, vol. xxv, 1914, p. 193, where the Daw End (Rushall) examples are referred to on p. 210.

[2] Ed. 2, pp. 112–117.

Fossils from the Barr (Woolhope) Limestone.

Clathrodictyon sp., 3.
Cyathophyllum sp., 3.
Cystiphyllum ?, 4, 5.
Favosites forbesi *Edw. & Haime*, 3.
Halysites catenularia (*Linn.*), 3, 5.
Heliolites sp., 3, 5.
Thecia swindernana (*Goldf.*), 3, 5.
Atrypa reticularis (*Linn.*), 3, 5.
Leptaena rhomboidalis (*Wilck.*), 4.
Lingula symondsi *Dav.*, 5.
Orbiculoidea forbesi *Dav.*, 2.
  ,, rugata (*J. de C. Sow.*), 5.
Orthis (Bilobites) biloba (*Linn.*), 1.
  ,, bouchardi *Dav.*, 3.
  ,, (Dalmanella) elegantula *Dalm.*, 1.
  ,, (Hebertella) rustica ? *J. de C. Sow.*, 3.
  ,, sp., 2, 5.
Plectambonites transversalis (*Wahl.*), 1, 4, 5, 6.
Rhynchonella sp., 1.
Spirifer crispus (*His.*), 2, 4.
Uncinulus ? stricklandi (*J. de C. Sow.*), 5.
Wilsonia ?, 2.
Illaenus sp., 2, 6.
Phacops downingiae (*Murch.*), 6.

Loc. 1.—Old quarry, 400 yds. S.E. of Aldridge Lodge. Staff. 63 NE. Eλ1.—Pl. 3404–8.
,, 2.—Dingle, 450 yds. S. of Aldridge Lodge. Staff. 63 NE. Eλ2.—Pl. 3409–19.
,, 3.—Old quarry, 300 yds. N.W. of the Three Crowns. Staff. 63 SE. Eλ7.—Pl. 3420–30.
,, 4.—Old quarry in Spinney, 200 yds. E. by N. of Daffodil Farm. Staff. 63 SE. Eλ11.—T.C.C. 2092–96.
,, 5.—Old quarry, 170 yds. S. of Daffodil Farm. Staff. 63 SE. Eλ9.—Pl. 3439–54.
,, 6.—Brook-course 300 yds. N.N.E. of Fiveways Bridge (on the Rushall Canal). Staff. 63 SE. Wλ3.—Pl. 3698–3704.

Other specimens, obtained at an earlier period and preserved in the Jermyn Street collections, are given in the following list, whenever it has been possible to assign them to a recognizable locality. They appear to have been presented by various donors, whose descriptions of the sources of the specimens suffer from a want of precision now past correction.

Barr Limestone Fossils (old collections).

Heliolites interstinctus (*Linn.*), 1, 2.
Horiostoma centrifuga (*Wahl.*), 1.
  ,, discors (*J. Sow.*), 4.
  ,, globosa (*Schloth.*), *var.* sculpta *J. de C. Sow.*, 1.

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[1] In the list of localities the symbols Eλ1, Wλ3, etc., correspond to symbols marked upon copies of the six-inch geological maps preserved in the Geological Survey Office. The specimens of fossils are identifiable by their numbers as registered in the Palæontological Department of the Geological Survey, *e.g.*, Pl. 3404–8. Thus the entry, Staff. 63 NE. Eλ1, Pl. 3404–8, signifies that the specimens bearing the registered numbers Pl. 3404–8 were found at locality 1 in the eastern half of the six-inch sheet Staffordshire 63 NE.

Orthoceras annulatum *J. Sow.*, 1.
Omphyma turbinatum (*Linn.*), 3.
Barrandella linguifera (*J. de C. Sow.*), 5.
Spirifer elevatus (*Dalm.*), 5.
Illaenus barriensis (*Murch.*), 5.

Loc. 1.—'Hay Head,' 'Wenlock Limestone.' Doubtless the Hay Head limeworks (now abandoned), 300 yds. N.W. of the Three Crowns (*see* Loc. 3 of previous list, p. 12).

„ 2.—'Red House, Walsall,' 'Wenlock Limestone.' Possibly an old quarry 170 yds. S. of Daffodil Farm (*see* Loc. 5 of previous list).

„ 3.—'Ginity Graves, Walsall,' 'Wenlock Limestone.' Possibly the same as 'Red House,' or some exposure farther to the south-west.

„ 4.—'Wood End, Walsall,' 'Wenlock Limestone.' The same as 'Red House.'

„ 5.—Various ill-defined localities, all referable to some part of the Barr Limestone outcrop. They are given as 'Great Barr' and 'Barr Beacon.' Some of the specimens are referred to the Wenlock Limestone, others to the Woolhope.

From the Wenlock Shale fossils have been collected at several localities, the best of which is the cutting on the Midland Railway at Daw End (pp. 17-19). The specimens, which were obtained from the uppermost 200 ft. of the formation exposed in the southern side of the cutting, are given in the following table:—

Fossils from Wenlock Shale, Daw End Cutting.

Cyathophyllum sp., 2, 3.
Cystiphyllum ?, 4.
Favosites forbesi *E. & H.*, 2, 5.
Halysites catenularia (*Linn.*), 4.
Omphyma subturbinatum (*d'Orb.*), 2.
Cornulites serpularius *Schloth.*, 1.
Atrypa marginalis (*Dalm.*), 5.
„ reticularis (*Linn.*), 1, 2, 3, 4, 5.
Camarotoechia cuneata (*J. de C. Sow.*), 4.
Leptaena euglypha *His.*, 5.
„ rhomboidalis (*Wilck.*), 4, 5.
Meristina tumida (*Dalm.*), 1, 2, 3, 4, 5.
Plectambonites transversalis (*Wahl.*), 1, 4.
'Rhynchonella' sp., 1.
Sieberella galeata (*Dalm.*), 1, 4, 5.
Spirifer elevatus (*Dalm.*), 5.
„ plicatellus (*Linn.*), *var.* globosus *Salt.*, 1, 4, 5.
Stropheodonta imbrex (*Pander*), *var.* semiglobosa *Dav.*, 3.
Wilsonia wilsoni (*J. Sow.*), 1, 2, 3, 4.
Cyclonema ?, 1.
Loxonema ?, 1, 2.
Platyceras cornutum (*His.*), 2.
Encrinurus punctatus (*Brünn.*), 1, 5.
Phacops caudatus (*Brünn.*), 3.

Loc. 1.—East of Bridge 61. About 200 to 175 ft. below Wenlock Limestone. Pl. 3519—3549.

Loc. 2.—West of Bridge 61. About 175–150 ft. below Wenlock Limestone Pl. 3550–3565.

Loc. 3.—East of Bridge 62. About 150–100 ft. below Wenlock Limestone. Pl. 3566–3578.

Loc. 4.—West of Bridge 62. About 100–50 ft. below Wenlock Limestone Pl. 3579–3590.

Loc. 5.—West of Bridge 63, from 20–0 ft. below Wenlock Limestone. Pl. 3591–3610.

From the shallow excavations in the Wenlock Shale at the now disused brick-works opposite the northern end of Beacon Street, at the Chuckery, Walsall, were collected[1] the following:—

Cyathophyllum ?
Favosites fibrosus (*McCoy*)
Atrypa reticularis (*Linn.*)
Orthis bouchardi *Dav.*
Rhynchonella cuneata (*Dalm.*)
Sieberella galeata (*Dalm.*)
Stropheodonta imbrex (*Pander*), *var.* semiglobosa *Dav.*
Wilsonia wilsoni (*J. Sow.*)
Cyclonema ?

In the Museum at Jermyn Street many fossils from the Wenlock Shale are preserved. The localities represented are now difficult to recognize, and it is not certain that some of the specimens attributed to the Wenlock Shale did not come from the Nodular Beds between the two bands of Wenlock Limestone. A locality known as the 'Bell' was probably a wharf or a cutting on the Rushall Canal, near the Bell Inn, on the Birmingham Road, 1½ miles south-east of Walsall. The horizon would be not far above the base of the Wenlock Shales. The locality known as the 'Five Lanes' appears to be the cutting on the same canal, between the Birmingham Road and a bridge, 350 yards farther north, now called Fiveways Bridge. The horizon would be slightly lower than that of the Bell. From these two localities the following are preserved in the collection at Jermyn Street. The numbers refer to the localities:—

Atrypa reticularis (*Linn.*), 1.
Dinobolus davidsoni (*Dav.*), 1, 2.
Orthis (Rhipidomella ?) hybrida *J. de C. Sow.*, 1.
Spirifer elevatus (*Dalm.*), 1.
Stropheodonta pecten (*Linn.*), 1.
Cypricardinia planulata (*Conrad*), 1, 2.
Leptodesma sp. nov., 1.
Modiolopsis nilssoni (*His.*), 2.
Gomphoceras pyriforme ? (*J. de C. Sow.*), 2.

Loc. 1.—Canal near the Bell Inn, 1½ miles S.E. of Walsall.

Loc. 2.—Canal between Birmingham Road and Fiveways Bridge, 1½ miles S.E. of Walsall.

At the time when the Wenlock Limestone was being quarried by openworks and shafts at Daw End, near Rushall Hall, and at what is now the Arboretum in Walsall, opportunities for the collection of fossils must have been abundant. But most of these sources of specimens are now inaccessible: the open quarries are either overgrown or full of water, and, with the exception of the Phœnix pit at Daw End, the shafts are disused.

The best section at the present time is that afforded by the Midland Railway at Daw End (p. 17), in which the Lower or Thick Limestone is well exposed east of and within 100 yards of the canal aqueduct. From this locality the following[2] have been obtained;—

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[1] Staff. 63 SE.WA2.—Pl. 3474–3494.
[2] Registered numbers Pl. 3611–3674.

Fossils from the Lower Wenlock Limestone, Daw End Cutting.

Cyathophyllum sp.
Cystiphyllum cylindricum ? *Lonsd.*
Favosites aspera *d'Orb.*
Halysites catenularia (*Linn.*)
Heliolites interstinctus (*Linn.*)
  ,, megastoma (*McCoy*)
Omphyma subturbinatum (*d'Orb.*)
  ,, turbinatum (*Linn.*)
Pachypora cristata (*E. & H.*)
Syringopora fascicularis (*Linn.*)
Thecia swindernana (*Goldf.*)
Anastrophia deflexa (*J. de C. Sow.*)
Atrypa imbricata (*J. de C. Sow.*)
  ,, marginalis (*Dalm.*)
  ,, reticularis (*Linn.*)
Glassina laeviuscula ? (*J. de C. Sow.*)
Leptaena rhomboidalis (*Wilck.*)
Rhynchotreta cuneata (*Dalm.*)
Sieberella galeata (*Dalm.*)
Spirifer elevatus (*Dalm.*)
  ,, (Cyrtia) exporrectus (*Wahl.*)
  ,, plicatellus (*Linn.*)
Cyclonema ?
Horiostoma discors (*J. Sow.*)
  ,, ,, *var.* rugosum *J. Sow.*
Platyceras cornutum (*His.*)
Orthoceras ?
Calymene blumenbachi *Brongn.*
Phacops sp. (spine)

In the Jermyn Street collections a number of fossils are preserved from the Wenlock Limestone of the Walsall district, but either the localities are not given in sufficiently precise terms; or there is some uncertainty as to whether they were obtained from the Lower Limestone, the Upper Limestone, or the intermediate Nodular Beds.

During the recent re-survey fossils have been obtained from the Nodular Beds at several localities. The best and most accessible of these are to be found at Daw End, where the root of the Lower Limestone has collapsed into the old Linley workings and exposed the overlying Nodular Beds in the sides of the resulting 'sinks' or 'crownings-in.' From two of these sinks the following have been collected. The numbers refer to the localities:—

Chonophyllum ?, 1.
Cyathophyllum sp., 2.
Aulopora sp., 1.
Favosites aspera *d'Orb.*, 2.
Halysites catenularia (*Linn.*), 2.
Heliolites interstinctus (*Linn.*), 2.
Plasmopora tubulata (*E. & H.*), 2.
Atrypa reticularis (*Linn.*), 1, 2.
Camarotoechia borealis (*Schloth.*), 2.
Leptaena rhomboidalis (*Wilck.*), 1, 2.
Meristina tumida (*Dalm.*), 1.
Orthis (Platystrophia) biforata ? (*Schloth.*), 2.
Horiostoma globosa (*Schloth.*), 2.

Loc. 1.—Sink in Nodular Beds, 400 yds. E. by N. of Royal Oak, Daw End. Staff. 63 NE. Eλ3.—Pl. 3495–3500.

Loc. 2.—Sink in Nodular Beds, 450 yds. N.E. of Royal Oak, Daw End. Staff. 63 NE. Eλ4.—Pl. 3501–3518.

The 'self-lumps' or 'ballstones' that occur in the Lower Limestone and also in the Nodular Beds have been described on p. 11). From some ballstones in the latter the following fossils fossils were collected[1] at the old quarries and sinks 100 yards south of Brawn's Works Bridge over the canal at Daw End:—

Arachnophyllum typus ? *McCoy*
Favosites forbesi *E. & H.*
Halysites catenularia (*Linn.*)
Heliolites megastoma (*McCoy*)
Plasmopora grayi (*E. & H.*)
Thecia swindernana (*Goldf.*)
Herpetocrinus ammonis *Bather*

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[1] Staff. 63 NE. Wλ2.—Pl. 3675–3684.

From the Upper or Little Limestone there are now no good opportunities of collecting. The rock was quarried at the Radleys, Daw End (p. 20), but only the uppermost or passage-beds leading up to the Lower Ludlow are exposed. These passage-beds yielded[1] the following:—

Tentaculites ornatus *J. de C. Sow.*
Atrypa reticularis (*Linn.*)
Leptaena rhomboidalis (*Wilck.*)
Orthis elegantula *Dalm.*
Stropheodonta filosa (*J. de C. Sow.*)
Wilsonia wilsoni (*J. Sow.*), *var.* davidsoni *McCoy*

Local Details.

Barr Limestone.—East of Walsall and north of the village of Great Barr, this limestone rises from beneath the Wenlock Shales in an outcrop that can be traced mainly by a line of overgrown quarries from south-east of Aldridge Lodge, past Gillity Greaves (east of Brook House Farm), as far as the northern edge of Sheet 168.

At the northern end of the outcrop the limestone was worked in a dingle south-east of Aldridge Lodge, and a quarry-face shows about 20 ft. of buff-weathering shales, in beds 9 to 12 in. thick, alternating with nodular limestones 3 to 6 in. thick. The thickness of beds once worked here would be about 26 ft. About 40 years ago the limestone was raised by a shallow shaft sunk through the lowest beds of the Wenlock Shales in the valley south-west of Aldridge Lodge; but with this exception all the stone was got by openwork, and burnt in open horseshoe-shaped kilns, particularly at the Hay Head Limeworks north-west of the Three Crowns on the Sutton Road. Immediately south of that road some old excavations in the eastern side of a spinney east of Daffodil Farm (Daffodilly of the Old Series one-inch map) show some few feet of beds that dip east-south-east. A little beyond this a gully south-east of the farm shows a good section that throws much light upon the structure of the outcrop. At the north-western end, near the farmhouse, the Wenlock Shales can be seen to pass downward into the Barr Limestone, with a dip to the north-west of 8° to 11°. South-eastward, up the gully, the beds flatten, turn over on the axis of a gentle anticline, then dip south-eastward at 8°, and are finally cut off by the boundary-fault, which brings in the Coal Measures (p. 117).

About 120 yds. south-west of Daffodil gully an old quarry-face shows about 12 ft. of nodular limestones in beds up to 9 in. thick, alternating with buff shales. The southernmost section, in a brook-course 300 yds. south-west of Gillity Greaves (Ginity Graves of the Old Series one-inch map), exposes about 4 ft. of similar nodular beds, and was included within the Wenlock Shale outcrop on the old map.

Wenlock Shales.—East of Walsall these occupy a large low-lying district bounded on the north-east by the Clayhanger Fault, which throws down the Coal Measures, and on the west by the Wenlock Limestone and the unconformable base of the Coal Measures. The beds dip about N. 25° W. at 5° or 6°, from which a thickness of 600 or 700 ft. for the formation can be inferred.

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[1] Staff. 63 NE. Wλ3.—Pl. 3685–3697.

Cuttings made over 60 years ago during the construction of the Rushall Canal yielded many fine suites of fossils, but the sections are now overgrown. The only good section now available is that afforded by a cutting on the Midland Railway, south of Daw End, excavated in 1877; but this shows only the uppermost 200 ft. The rocks consist of grey shales with occasional thin limestones (an inch or so thick), which become more abundant toward the top of the subdivision. Both shales and limestones are richly fossiliferous, and the fossils in the shales can be picked out in an excellent state of preservation.

On the Old Series one-inch map (62 S.W.) is shown a short lenticular outcrop of limestone in the Wenlock Shales one-fifth of a mile north-west of Halfway House (now College Farm).[1] The spot is marked by an old quarry, which shows about 20 ft. of shales and thin-bedded nodular limestones. These strike north-eastward into the Daw End railway-cutting, 200 yards away, where they have much the same character and can be seen to lie about 60 ft. below the Wenlock Limestone. Whether the quarry worked the beds now visible, or, as Jukes thought, was opened on some self-lumps or ballstones (p. 11), there is now no evidence to show.

Wenlock Limestone.—This subdivision consists of three members; (1) the Lower or Thick Limestone; (2) the Nodular Beds; and (3) the Upper, Thin, or Little Limestone.

The Lower or Thick Limestone.—The most northerly workings on this band commence at the side of the canal a quarter of a mile south of Linley Farm. As no signs of working are visible to the north-east it is probable that the Clayhanger Fault crosses the canal at this point and terminates the outcrop in that direction. South-westward the overgrown openworks lead us to a small coppice in which the limestone was formerly dug from below a few feet of Coal Measure sandstones, of which there is abundant debris. Immediately to the south the deep cutting on the Midland Railway[2] (already alluded to) affords some instructive sections in the Lower Limestone, the Wenlock Shales (p. 13), and the basement beds of the Coal Measures. The interpretation of the sections is governed by the fact that a fault, with southerly upthrow, runs along the cutting and has shifted all the outcrops westward on its southern side. Though nowhere actually visible, the fault can be closely located towards the eastern end of the cutting (near the bridge numbered 61), where the Wenlock Shales on the north side contain abundant thin limestone-bands and dip north-east and north at 25°, while on the opposite side the shales contain fewer limestones and dip westward along the cutting at 8°. Here the fault runs probably under the rails; but westward it gradually mounts the northern side till at the canal aqueduct it is coincident with the boundary-fence. Still farther westward it appears to have been met with in the shaft of the abandoned Fuller's Earth Works. On the north side of the fault the Lower Limestone is exposed in the cutting at 75 yds. east of the road-bridge (62), where it dips about north-west at 12°. The rock, of which a thickness of about 25 ft. is exposed, is somewhat undulating as regards its bedding. It consists of richly coralline limestone in bands, averaging less than 6 in. but occasionally ranging up to 9 in., separated by thin films of shale.

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[1] Jukes, *op. cit.*, ed. 1, 1853, p. 269; ed. 2, 1859, p. 160.

[2] See J. W. Oliver in *Proc. Dudley and Midland Geol. Soc.*, vol. iii, 1877, p. 111.

Between the road-bridge (62) and the milepost 46 the northern bank shows at the top the Coal Measure sandstones, underlain by the Nodular Beds, below which the Thick Limestone can be detected; but west of this the limestone is cut off by the fault.

The openworks on the outcrop of the Lower Limestone, abandoned long ago, were succeeded by shallow shafts, and by a drift that descended through the basement beds of the Coal Measures and the lowest of the Nodular Beds into the limestone below. From these underground workings, known as the Linley Caverns, the stone has been extensively extracted, except that left as pillars to support the roof. Still farther to the north-west, in the direction of dip, the limestone has been raised by deep shafts at Brawn's Lime Works and at the Winterley Lime Works, now both abandoned. These shafts must be 60 to 75 yds. deep. Two others are situated about 100 yds. north of the road-bridge over the canal at Daw End. At 70 yds. south of the bridge the shaft of the Phœnix Lime Works, 59 yds. deep, is the only one now raising the stone, which is used for flux and lime. In these workings the bed dips north-west at 3½ in. or 4 in. per yard, *i.e.*, about 5° or 6°.

Reverting to the railway-cutting, the base of the Lower Limestone south of the fault crosses the rails at 72 yards east of the canal aqueduct and dips a little north of west at 10°. The uppermost of the Wenlock Shales, consisting of shales with limestones, pass up into the Limestone. On the north side of the cutting the Limestone itself, consisting of alternating thin-bedded limestones and shales, is exposed to a thickness of about 27 ft., though the top is not visible. The section[1] shows three of the large ballstones or self-lumps alluded to on p. 11. The westernmost measures 48 ft. from side to side, is 15 ft. thick, and consists of massive unstratified coralline limestone. Its top, which must once have been immediately covered by the basement-beds of the Coal Measures, has been partially converted into dark red hematite. The ballstone rests on limestones, more than usually thin-bedded and averaging 1½ in., separated by shale partings. These thin-bedded limestones sag down beneath the ballstone. The middle ballstone is 15 ft. from side to side and 8 ft. thick, while the easternmost one is smaller; both appear to be made up chiefly of chain-coral and have likewise caused the beds below to sag. The section is terminated westward by some joint-faces, beyond which the limestone is invisible, the banks of the cutting being occupied by soft materials, apparently used to fill in an old excavation, known as the Blue Hole,[2] which seems to have extended westward beyond the canal aqueduct.

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[1] Survey Photograph No. 1540.

[2] Willmore, F. W., 'Records of Rushall,' 1892, pp. 117, 118.

West of the aqueduct the cutting shows the Nodular Beds overlain by a few feet of yellow and black shales and ironstones of the Coal Measures. Southward the outcrop of the Lower Limestone is traceable by the old water-filled excavation known as the Park Pits (east of Rushall Hall), along the western edge of which the Coal Measures can be seen overlying the Nodular Beds, but the Limestone itself is not visible. At its southern end the excavation terminates abruptly, presumably against a fault shown on the Old Series map.[1] Moreover, the Coal Measures and Glacial drift appear to have made too thick a cover to allow of the limestone being worked easily. The fault being a southerly upthrow would shift the crop westward, and in consequence the rock reappears from beneath the Coal Measures in some deep old excavations between the Mellish Road and Moss Close Farm, in the northern suburbs of Walsall. In these the Limestone is visible only at one point: in the grounds of Moss Close House, where, 50 yards south of the house, several feet of it, with an abnormal dip to the south-west at 50°, and overlain by the lowest of the Nodular Beds, are exposed at the foot of a steep bank in which the Nodular Beds, dipping N. 20°—40° W. at 10° to 15°, are faulted down against it on the east. The fault, which ranges about north-west, toward The Butts, is shown on the Old Series map and is mentioned by Jukes.[2]

South-west of Moss Close House the Lower Limestone was extensively worked in openworks, now the site of the Arboretum lake. There is a small exposure of limestone, at the water's edge 100 yards north-east of the band-stand, that may be in place, while the opposite side of the lake, at the end of Victoria Terrace, shows a cliff[3] of the overlying Nodular Beds, dipping north-west at 10°. On the higher ground south-east of the lake there are old shallow workings behind the gardens of Arboretum Road.

South of the Arboretum the Limestone is nowhere visible; but it was being worked in 1782 in a large openwork, on the western side of Ablewell Street, between The Ditch and Hill Street, at the foot of the bank of Glacial gravel on which stand the church and the older and higher parts of the town. A little south of this, at the Wheatsheaf, the Moat Fault, a southerly downthrow running east-and-west along Birmingham Street, crosses the ground and brings down the basement-beds of the Coal Measures. It should have the effect of shifting the Limestone outcrop farther east, but south of it no outcrop of limestone is known; and some recent sewer-sections in the Sutton Road opposite Bernard Street showed nothing but Wenlock Shale. A well at the Highgate Brewery, for the record of which we are obliged to Messrs. Fletcher and Garbett, proved the base of the Coal Measures at a depth of 47½ ft., below which followed 'limestone binds with bands of stone,' 69 ft. thick (p. 94). This description does not suggest the Lower Limestone, but whether the beds in the well overlie or underlie that rock remains uncertain.

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[1] Jukes mentions this fault, *S. Staff. Coalfield*, ed. 1, 1853, p. 269; ed. 2, 1859, p. 160.

[2] *Loc. supra cit.*

[3] Survey Photograph No. 1541.

North of the Moat Fault the Lower Limestone is known to extend westward underground with a gentle dip, and to underlie the northern part of the town of Walsall. It was formerly raised by a shaft and burnt at Crapper's Limeworks (220 yards north of Littleton Street West and 100 yards west of the railway). Farther west it was raised at Birchills, where it dips west, by a pair of shafts that reached it through the cover of Coal Measures. Jukes[1] records that at Bentley a pit was sunk that proved the Upper Limestone to be 12 ft. thick, the Nodular Beds 118 ft., and the Lower Limestone 33 ft. 9 ins.; while another pit at Ryecroft proved the same bands to be respectively 12 ft., 120 ft., and 36 ft. thick.

The Nodular Beds.—Besides the small exposures mentioned above, these beds are excellently displayed at Daw End, in a number of sinks or 'crownings-in' above the Lower Limestone. Some old excavations and sinks immediately south of Brawn's Works Bridge on the canal are of special interest as showing some fine ballstones or self-lumps—a somewhat unusual feature in the Nodular Beds.[2] The ballstones are compact unbedded masses of coral, against which the thin-bedded nodular limestones abut on each side. The Nodular Beds can be seen in the Daw End railway-cutting west of the canal aqueduct, and are just visible here and there in the western bank of the Park Pits and of the Arboretum Lake.

The Upper or Little Limestone.—North of Daw End this band emerges from the western side of the Clayhanger Fault and is traceable along a line of old workings past Radley Bank to The Radleys. Here in a quarry immediately north of the cottages are exposed a few feet of buff shales with thin blue shelly limestones, which no doubt closely overlie the Upper Limestone, though that rock is no longer visible. These beds must consequently be regarded as passage-beds leading to the Lower Ludlow formation. The limestone was sunk-to in a pair of shafts, said to be 18 yards deep, 250 yards west-south-west of The Radleys, while in a garden 150 yards south of The Radleys it is said to have been quarried through the basement-beds of the Coal Measures. Beyond this point, however, these beds cover it too deeply, and it does not show itself again till we reach Walsall. It must have been passed through in the deep shafts sunk to the Lower Limestone at the Winterley Lime Works and at Brawn's works at Daw End, but no record of these shafts is known to exist; nor is anything known of its presence in the Phœnix shaft sunk in 1882.

In Walsall, Jukes referred the beds exposed in the railway-cutting, north-east of the station, to the Upper Limestone; but Dr. Gibson is of opinion that they belong rather to the Nodular Beds, in which case the Upper Limestone would crop out a little to the north-west of the cutting.

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[1] Jukes, *op. cit.*, ed. 1, p. 223; ed. 2, p. 84.

[2] *Op. cit.*, ed. 1, p. 269: ed. 2, p. 160.

The sections recorded by Jukes of the Bentley and Ryecroft shafts show that not only the Upper Limestone, but also as much as 214 ft. of Lower Ludlow beds above it must underlie the Coal Measures west and north of Walsall.

At Chasetown, a boring from the bottom of one of the shafts at the Cannock Chase No. 2 Plant (p. 83) proved, below the supposed Old Red Sandstone about 69 ft. of sandstone and 48 ft. of shale and grit, all more or less red. There is no means of deciding whether these also are Old Red Sandstone, or Silurian Passage-Beds. Below followed 513 ft. of light-coloured rock, with partings in the last 7 ft. These may well have been Silurian. Beneath them came 102 ft. of limestones, which were supposed to be Silurian. This thickness is too great for either the Aymestry or the Barr Limestone, so that presumably the rocks in question are Wenlock Limestone. But in the absence of specimens even their Silurian age remains doubtful.

OLD RED SANDSTONE.

By W. GIBSON.

In the Walsall area the highest Silurian strata are the Lower Ludlow Shales. At Ellowes Park, Turner's Hill, Sedgley, 7 miles S.W. of Hollybank Colliery (p. 106), the Upper Ludlow Shales have been shown by Mr. Wickham King and Mr. W. J. Lewis[1] to be succeeded by red and purple sandstones and marls, 315 ft. thick and belonging to the higher part of the Temeside (Downtonian) Group.

In No. 15 Shaft, Hollybank Colliery, Coal Measures inclined at 12° W., rest on red and purple sandy marls, dipping 30° in the same direction and recently shown by Mr. King (*op. cit.*) to contain fossils of the Temeside Group. At a distance of 1,000 yards from the pit-bottom, a rising drift (Hilton Tunnel, fig. 4, p. 109) enters red and purple sandstones and marls inclined westwards at a much higher angle than the Coal Measures (1 in 9). With the exception of worm-burrows and fragments of *Cephalaspis* no fossils have been found; but, in the absence of faulting, they must be much higher in the sequence and may possibly be of Old Red Sandstone age. They may, however, belong to a less fossiliferous part of the same set of beds as those in the pit-bottom.

In the Cannock Chase No. 2 Pit (p. 83), the basement-bed of the Carboniferous rocks rests on purple 'clay slate,' red and brown sandstone, and red 'clay slate,' 214 ft. 8 in. thick. These red measures may be Old Red Sandstone.

Again, the same formation may have been met with in a boring put down from the bottom of the No. 1 Shaft of the Fair Oak Colliery, 2 miles west of Brereton (p. 75). The shaft and boring, after traversing Trias and Upper Carboniferous down to 871 ft. 4½ in., passed through 104 ft. 2 in. of red, brown and variegated sandstones and shales, in which the boring ended at a depth of

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[1] 'The Downtonian of South Staffordshire.' *Proc. Birmingham Nat. Hist. and Phil. Soc.*, vol. xiv, 1917, p. 92.

975 ft. 6½ ins. If these red beds are Old Red Sandstone or Downtonian Passage-Beds (Silurian), they must be separated from the overlying Upper Carboniferous beds (Coal Measures or Millstone Grit) by a fault; otherwise the Carboniferous Limestone (p. 24), proved in a trial-heading from the same shaft, would have intervened. But in the absence of specimens the age of the beds in question remains unsettled.

CHAPTER III.

CARBONIFEROUS ROCKS.

GENERAL ACCOUNT.

By G. Barrow.

The Carboniferous rocks occurring within the area under description include in descending order:—

	South Staffordshire (North of the Bentley Fault). feet.	Warwickshire (Tamworth District). feet.
Hamstead Group (upwards of 1,800 ft. at Streetly) ...	absent	absent
Keele Group	900	900
Halesowen Group	350–400	350–400
Etruria Marl Group	upwards of 700	50–256
Middle Coal Measures ...	850–1,200	850
Millstone Grit	mostly absent, but met with in mining	mostly absent, but possibly met with in mining.
Carboniferous Limestone ...	do.	absent, so far as known.

The character of the Upper Coal Measures indicates that they were deposited in the same basin as those of North Staffordshire, for in both areas the same general sequence is observable, but the parallellism ceases with the Carboniferous rocks older than the Etruria Marls. The group of Blackband Ironstones of North Staffordshire is unrepresented and it is not practicable to correlate individual seams of coal or groups of seams of the South Staffordshire or Warwickshire coalfields with those of North Staffordshire. If the rocks older than the Etruria Marls belong to the same basin in both areas it is evident that the southern margin of the basin was not far distant, for the Middle Coal Measures show a marked attenuation in that direction. Indeed, as regards the Millstone Grit and Carboniferous Limestone the margin may have been closely approached, for both in South Staffordshire and Warwickshire these subdivisions are overlapped by the Middle Coal Measures. But it must be noted that in places there exists at the base of the Coal Measures a coarse conglomerate, in which are included blocks derived from the Carboniferous Limestone and Millstone Grit, showing that both had been subjected to denudation and may have originally extended beyond their present limits.

Conversely as we go north from this margin these two lower divisions should gradually come on, and the occurrence of Carboniferous Limestone in a heading at Fair Oak, within the Cannock Chase district, as described below, gives some clue as to the position of the line along which this occurs. The Millstone Grit is likely to set in before the Limestone, but is difficult to identify.

The only occurrence of Carboniferous Limestone as yet known in the South Staffordshire Coalfield is that met with in the Fair Oak Colliery, 2 miles west of Brereton. Here a shaft and boring (p. 75), made in 1872-1875, penetrated 449 ft. of Carboniferous rocks (under Trias) and then passed directly into what appeared to be Old Red Sandstone. But at the end of one of two headings, driven a little above the bottom of the shaft at a depth of about 740 ft. from the surface, shaly limestone and calcareous sandstone were encountered. The fact that the Coal Measures rest on Silurian Limestone farther south led to the assumption that the limestone of the Fair Oak heading also was of Silurian age, and this view was not challenged till 1904, when Mr. G. Wetherall obtained fossils from the spoil-heaps. These were shown to Mr. G. M. Cockin[1] and Prof. Bonney, who identified them as being of Lower Carboniferous age. Later on, Dr. Wheelton Hind and Dr. Vaughan examined a fresh series collected by Mr. Cockin and found them to be characteristic of the Dibunophyllum zone, or the highest part of the Carboniferous Limestone. To the already published lists of fossils can now be added *Orbiculoidea nitida* (Phill.)[2]

The disposition of the strata met with in these explorations cannot as yet be explained. It is not certain that the red rocks were Old Red Sandstone and not red Carboniferous, nor is it known what faults were passed through (p. 22). The existence of Carboniferous Limestone is the one fact that emerges.

In the North Warwickshire area the Carboniferous Limestone has nowhere been met with, but in a boring at Desford, 16 miles east of Tamworth, the uppermost zone, with a thickness of 25 ft., was found to rest on the pre-Carboniferous floor.[3]

The Millstone Grit, though absent at the surface in this area, might be expected to exist in the northern part. It would be likely also to extend farther south than the Carboniferous Limestone along the southern margin of the basin, but its recognition becomes difficult under the changed aspect that is associated with littoral conditions, and in the absence of fossils. A further complication is due to the fact that the Lower Carboniferous rocks were subjected to denudation before the Upper Carboniferous were deposited, and that the original distribution of the earlier strata may not coincide with their present limits. For these reasons it is doubtful whether some of the strata proved underground belong to the Millstone Grit or represent the lowest part of the Coal Measures. In the eastern part of the district now under consideration, the strata that underlie the lowest coals have been proved only in the Peel Shaft at Wilnecote (pp. 269, 270), south of Tamworth. Here they consist of red and grey shales and coarse grits, which are possibly the equivalent of the red beds and coarse grey grits immediately above the limestone in the Desford boring, already referred to.

In the northern part of the South Staffordshire Coalfield, the age of the Carboniferous rocks below the lowest workable coal is more difficult to decide, as in the case of the Wolseley Park (Sheet 140), Fair Oak and Cannock Chase No. 2 Pit. In these, Lower Coal Measures or Millstone Grit, or both, may be present.

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[1] G. M. Cockin, *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 523; also *Trans. Fed. Inst. Min. Eng.*, vol. xli (pt. 3, 1911), p. 323.

[2] T.C.C. 2120.

[3] Leicestershire and South Derbyshire Coalfield (*Mem. Geol. Survey*), 1907, p. 347.

The grouping of the Coal Measures given in the table (p. 3), has been adopted for local convenience. Thus the use of the terms Upper and Middle Coal Measures does not imply a correlation with the Upper and Middle Coal Measures of other coalfields. As here applied the term Upper Coal Measures expresses the fact that a considerable thickness of measures, without workable coals, occurs in conformable sequence above measures which contain the more important seams of coal and are generally called Middle Coal Measures. Below these in Lancashire, North Staffordshire, Yorkshire, Derbyshire, Nottinghamshire and Leicestershire there lies a considerable thickness of measures named Lower Coal Measures, which have not been recognised with certainty as occurring in Warwickshire and South Staffordshire. Among the Upper Coal Measures the Etruria Marl Group and the Keele Group are of the same types as in North Staffordshire, and as these names are already in local use they are retained; but conforming to local custom the term Halesowen Group is substituted for the equivalent Newcastle-under-Lyme Group of the North Staffordshire region. The Keele Group is now generally accepted as belonging to the Coal Measures. In the area between the two coalfields the Keele Beds are succeeded by over 2,000 ft. of red sandstones and marls without coals but generally distinguishable from the red sandstones and marls of the Keele Group by the presence of conglomerates containing pebbles of Carboniferous or Silurian limestones, cherts and quartzites. As these higher strata are closely connected with the Keele Group they are provisionally retained in the Carboniferous System under the local name of Hamstead Group.

In North Warwickshire the full thickness of the Middle Coal Measures has been proved to be about 850 ft. at Wilnecote. At Aldridge, on the same latitude in South Staffordshire, the thickness amounts to 1,000 ft., and northwards a gradual expansion to over 1,200 ft. sets in in the Hednesford region. The measures of the two coalfields are similar in character but at present there are no certain data on which to found a correlation of the coal-seams.

Among the Upper Coal Measures the Etruria Marl Group is the most variable in thickness and character in both coalfields. In North Warwickshire it varies from 250 to about 50 ft. and may even occasionally disappear, possibly through becoming indistinguishable in colour from the underlying Middle Coal Measures. In the northern part of the South Staffordshire Coalfield the full thickness does not occur, but the group is over 700 ft. thick at Hollybank, on approximately the same latitude as the northern end of the Warwickshire Coalfield. The Halesowen Group maintains a thickness between 350 and 400 ft. in both areas. Direct measurements of the Keele Group are not available. Only the lower beds crop out in the Warwickshire portion and the basal part is faulted out in the South Staffordshire portion. At Hamstead Colliery the Keele Group is about 900 ft. thick.

The Hamstead Group is confined, as previously stated, to the region between the two coalfields, but on the whole it is not well exposed. This conglomeratic group was penetrated for a thickness of 1,830 ft. at Little Aston (Streetly) without reaching the base.[1]

The palæontology of neither of the areas of Carboniferous rocks has been fully worked out. The Middle Coal Measures are seldom seen at the surface and new sinkings are few, while in the past little attention has been paid to the fossils during sinking operations. The Keele Group and Hamstead Group are extremely unfossiliferous and no fossils have as yet been recorded from the area under description. Both are more fossiliferous to the south (Sheet 168) and are certainly better displayed.

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[1] Summary of Progress for 1911 (*Mem. Geol. Survey*), 1912, pp. 26, 27.

CHAPTER IV.

CARBONIFEROUS ROCKS, CONTINUED. THE NORTH WARWICKSHIRE COALFIELD.

By G. BARROW.

MIDDLE COAL MEASURES.

General Account.

At the date of the original survey of this coalfield a deep cutting on the Midland Railway, near Cliff, provided a good section of the coals and the strata associated with them, all dipping due east at angles of 75° to 80°.[1] The section is now greatly obscured and the coal-seams, though several are visible, can no longer be identified. Elsewhere, largely owing to downwash from the Etruria Marls, exposures are rare, but they suffice to show that sandstones are not present in large amount, and that such as are seen are fine-grained and impure. One or more beds above the Rider Coal are fairly continuous from near Dosthill Colliery to near Wilnecote, and there form a more conspicuous feature than the Halesowen Sandstone, but generally the sandstones occur as lenticles of no great length. In the shaft-sections they are termed 'cank' when cemented and hardened by iron-oxide. 'Peldon' is used generally for a hard rock, and is applied to various materials, including 'cank.' The term seems to be useful to account for slow progress in a sinking.

Grey hardened clay, known locally as bind or blue bind, is the dominant constituent in shaft-sections. It is fine in texture, with minute clastic micas, and though it occurs in bands it shows no bedding, but breaks up like a marl. In addition to these grey binds there are bands of white and pale-brown and almost black clays, which form valuable material for the manufacture of high-class pottery. Some of the bands are specially mined for this purpose (chap. xi). Shales appear to be more common below the lowest coal-seam worked, and thus have not often been penetrated.

Grey bind interbanded with sandy material, called rocky bind in shaft sections, is fairly common; where the sandy material is finest (the most common type) the fresh rock breaks across the bedding rather than parallel to it.

Associated with the coals are numerous beds of fireclay, some of which, like the clays mentioned above, are mined for pottery and higher class pipes and bricks.

Ironstone, in nodules arranged more or less in lines, occurs especially in the middle and lower part of the group and was formerly much mined. An account of the working of these nodules is given on pp. 208-213. The number of coal-seams known to exist in the North Warwickshire Coalfield is at least 22; of these 15 are less than 2 ft. thick, including 7 of only a foot or less; 7 are more than 2 ft. thick, and of these 5 have been mined. The following table gives a general view of the sequence near the centre of the area:—

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[1] 'The Geology of the Warwickshire Coalfield' (*Mem. Geol. Survey*), 1859, p. 25 and Plate 1, Section No. 3.

		Ft.
	Etruria Marls; the pottery-clays of Glascote (pp. 201, 202)	—
Middle Coal Measures.	Measures with pottery-clays at Glascote	150
	RIDER COAL	3
	Measures with White Ironstone (p. 212)	200
	SMITHY COAL	2
	Measures	50
	SEVEN FEET COAL	7
	Measures with Pottery Clays of Wilnecote (p. 202) and Brown Ironstone (p. 212)	90
	COAL 3 ft. Measures[1] 2 ft. COAL 5 ft. } DOUBLE COAL (average)	9
	Measures with Pottery Clays of Wilnecote (p. 202)	50
	BENCH COAL	4
	Measures with Pottery Clays of Wilnecote (p. 202) and Black Ironstone (p. 212); to the first conglomerate	270
	Total	835

The southward attenuation of the measures and changes in the coals are features of the North Warwickshire Coalfield. In the memoir published in 1859, on pp. 9 and 10, attention was drawn to this change, especially as regards the measures above the Seven Feet Coal, but the observations refer to an area a little south of that here dealt with. In the northern part of the field a small group of strata maintains a constant thickness for some distance, as do also the coals. Near and to the north of Watling Street the Seven Feet and the overlying Smithy Coal keep at about 60 ft. apart and vary little in thickness, but the higher beds above the Smithy Coal show the southward attenuation. Thus at Tamworth Colliery, at the north end of the field, these are about 440 ft. thick, while at Kingsbury, the most southerly shaft on the west side, they are only 286 ft. The included coal-seams above the Smithy show the reverse phenomenon, for they thin northwards, and in addition deteriorate, split up and become too thin to pay for working at present. At Tamworth the Rider, the most important seam immediately south of the Watling Street, is difficult to identify. There is reason to believe that this change continues northwards into Leicestershire where there is a great thickness of beds with numerous thin coal-seams at the top of the Middle Coal Measures.

The thinning southward of the beds below the Seven Feet Coal is less marked here than in the ground further south. It is accompanied by a change in the seam itself and by a still more marked change in the underlying Double and Bench Seams, which appear locally to thicken southwards. Generally speaking the Seven Feet, Double and Bench Seams are worked to the north of Watling Street, and increasingly towards the north, while the Rider, above the Seven Feet Seam, is the chief seam worked south of Watling Street.

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[1] The thickness of these varies greatly.

When the original geological survey of the coalfield was made, the raising of coal for general purposes was practically confined to the Seven Feet Coal, for the other seams were worked mainly in association with the underlying fireclays and pottery clays. Thus in the large royalty of the old Wilnecote Colliery, long since closed down, and in the Birch Coppice, No. 1, farther north, the Seven Feet Coal only was worked. The improvement of the lower seams northward is a later discovery and has led to a proposal to re-open the latter colliery to work the Bench, in which the northward improvement seems most marked.

Considerable additions have been made to our knowledge of the lowest beds of the Middle Coal Measures since the date of the original survey. In the memoir of 1859, on pp. 19, 20, Howell calls special attention to some beds proved in a shaft near the Hawksbury Basin (in Sheet 169). It is now clear that this shaft, after passing through about 220 ft. of Coal Measures, entered Cambrian rocks. Numerous bands and nodules of ironstone in the lowest measures are recorded in this section, and are known to occur at the same horizon all along the western side of the coalfield, but where the Cambrian rocks projected locally in an eminence, as at Dosthill, the shales with ironstone nodules were never deposited. It may be calculated that the eminence at Dosthill was fully 1,000 ft. high and steep-sided, for at a distance of only some 600 yards to the east the shales below the Bench Coal were penetrated to a depth of 40 ft. without reaching the base of the Coal Measures; two small seams of coal were met with in them.

These same strata were passed through in a boring at the Peel Shaft, a little north-east of Wilnecote Station (see section p. 269). The lower of the two thin seams was here 60 ft. below the Bench Coal, the intervening beds having nearly doubled in thickness. Below the coals some red marls were met with, succeeded lower down by some coarse grits. Similar marls and grits were found at Desford (Sheet 155) to overlie Carboniferous Limestone.[1] Again at Netherseal the shales with ironstones, red marls and coarse grits were found in sequence.[2]

Clearly there is a wide area fringing the northern end of the Warwickshire Coalfield in which there is no great thickness of grey measures below the Bench Coal, and there is no indication of the incoming of a number of additional and workable seams accompanied by a thickening of the measures, such as is suggested by the development in North Staffordshire. On the other hand, the two small seams met with near the base of the measures are thicker at Wilnecote than at Hockley Hall, and one of them may possibly become workable to the north.

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[1] Leicestershire and South Derbyshire Coalfield (*Mem. Geol. Survey*), 1907, p. 347.

[2] *Ib*, pp. 193–195.

The Seven Feet Coal, the chief seam, is persistently overlain by a small seam known as the Thin Coal, which is rarely worked for sending away. A typical section is as follows:—

	Ft.	In.
THIN COAL	2	0
Parting	1	6
SEVEN FEET COAL	6	0

The parting may vary from 6 in. to as much as 3 ft. Where it was thin the upper seam has at times been taken, but perhaps not sent away from the pit. In such cases the Thin Coal was taken in as part of the Seven Feet and the depth to the latter in some of the earlier shafts is really the depth to the top of the Thin Coal. In recent practice the Thin Coal is not counted in. In the following notes the depths quoted indicate the distance from the pit-top to the base of the seam.

The Seven Feet Coal varies considerably in character in different portions, as is shown by the account of it entered on the older plans deposited at the Home Office. That of the Birch Coppice, No. 1, may be taken as typical and is as follows:—

	Ft.	In.
Scarps	0	10
Top spires	0	10
Drilling dice	0	4
Bottom spires	2	6
Dun dick	0	10
Bottom dice	0	8
Total	6	0

The Scarps or Scorps are disliked as a fuel and usually left unworked, apparently because they burn to a very fine ash which blows about. Generally the upper part of the seam is harder and comes out in larger blocks than the lower part. The percentage of ash is distinctly larger in the area south of Watling Street than in that to the north.

Ferruginous nodules containing marine fossils may be collected on all the tip-heaps of the workings in this seam; they come from the shale above the Thin Coal and mark the only marine horizon as yet recorded in this part of the coalfield. The occurrence of marine conditions may have some connection with the rarity of the wash-outs which are so often met with in the other seams, especially the Rider (p. 37). A list of the fossils is given on p. 65.

DETAILS.

AREA NORTH OF WATLING STREET.

Birch Coppice Colliery, No. 1. (for shaft-section, see p. 249 and Plate).

Messrs. Morris & Shaw.

The royalty known as the Birch Coppice Colliery extends from the Glascote Road almost to the southern edge of the map. The workings are conducted from two shafts, but a third has been recently sunk for the pitmen in the southern part of the royalty. The most northerly shaft is situated some 300 yards south of the Glascote Road at the east edge of the map, and was known as Birch Coppice No. 1 or Cockspur Pit. It is now abandoned and the exact height of the old pit-top cannot be given; the present top is about 310 ft. above Ordnance Datum. The plans show that the seam dipped in a westerly or south-westerly direction towards the centre of the field, and also give the detailed section of the seam quoted above (p. 30). The coal is generally held to have attained its finest quality in this part of the coalfield. The thinning of the Rider Coal to the north of the Watling Street is shown here, for the seam was passed through in the shaft but was too thin to be worth working. The Seven Feet Coal only was worked, but it is now proposed to re-open this shaft and sink to the Bench Coal.

Kettlebrook Collieries (for shaft-section, see p. 259 and Plate).

To the west of Birch Coppice, No. 1, is the small royalty of Kettlebrook which was mined by two firms at different times. Two pairs of shafts were sunk, both close to the west side of the lane leading from Glascote to Wilnecote. The older and more southerly is known as Dumolo's shaft and the section of it was published in Vertical Sections of the Geological Survey, Sheet 21, Sect. No. 3.

The more northerly and newer is known as Cagg's pit, but is called Kettlebrook on the six-inch map. This was sunk to the Double Coal at a depth of 420 ft.; it is now abandoned and plans are deposited at the Home Office, but some additional information has been kindly supplied by Mr. Chas. Fisher.

At Dumolo's pit the Seven Feet Coal was 7 ft. 6 in. thick and of this 6 ft. were taken; the whole of the seam was extracted up to the large fault shown on the map west of the shaft, and the pit was then abandoned.

From Cagg's pit the Double Coal was mined for some distance about the shaft and a road was driven in the seam for 830 ft., due west, the rise throughout being about 1 in 5; the same fault was then reached and the seam was now about 235 ft. below the pit-top. The fault, which haded at a low angle and occupied a considerable breadth of ground, was then crossed and the road emerged a little below the Seven Feet Coal, which now dipped westward at a sharp angle. Some coal was worked here and two small faults were crossed, a larger one being met with further on, also throwing down west, which stopped the work and caused the pit to be abandoned. A small amount of the Smithy Coal and White Ironstone was also worked from this pit. There is thus a good sized patch of the Seven Feet and Double Coals left, while in no part of the whole royalty has the Bench been mined.

Wilnecote Colliery (for shaft-sections, see pp. 267-269 and Plate).

Westward of Birch Coppice No. 1 and stretching south to the Watling Street is the royalty worked from the old Wilnecote shaft, situated 300 yards to the north-east of Wilnecote Church and about 300 ft. above Ordnance Datum. Here again the Seven

Feet Coal only was worked, the last being 561 ft. down the shaft; the coal was all taken out up to the barrier and the pit closed down more than 50 years ago. The seam is shown on the plans at the Home Office to have been 6 ft. 4 in. thick, with much the same details as those given on p. 30. The shaft went through almost the whole of the Etruria Marls before reaching the grey measures and showed the occurrence of three thin seams in the lower part of the marls.

Wilnecote, Peel Royalty (for section of Peel No. 1 Shaft and boring, see pp. 269, 270 and Plate).

At the 'Peel Estate,' on which are now situated the large Wilnecote Brick and Tile Works, more beds were worked than elsewhere and a considerable number of shafts were sunk. In the S.W. part of the royalty are the Peel Shafts, Nos. 1 and 2; to the east, close to the Watling Street is the Chapel Pit, while to the north, at the junction of two lanes is the Corner Pit. Halfway between the last two was an old shaft used for working ironstone only, while the two Beauchamp Shafts have recently been put down toward the north end of the royalty.

The Seven Feet coal has been practically worked out. The Double and the Bench have also been extensively mined, but mostly in conjunction with the underlying clays, for the purpose of firing them. Indeed, another thin coal, considerably below the Bench, is taken to some extent, but only with the underlying clay. In addition, ironstone-nodules were formerly worked at several horizons. An account of these and of the clays is given on pp. 202, 206, 207. The Seven Feet Coal was 7 ft. thick on the average. About 6 ft. of it were taken, the upper foot, including the scarps or scorps, not being usually saleable.

The Double Coal shows the following details:—

	Ft.	In.
COAL	2	7
White clay	1	6
COAL, about	3	0
White clay, average	3	3

The lower three beds are worked. The workings in the Double Coal are conducted from the new Beauchamp Pits. The Bench Coal averages 4 ft. 10 in. in thickness; it burns slowly and is valuable for calcining, but is not usually sent away. Immediately below it is a bed of hard dark shale, known as 'Alum-shale,' about 1 ft. 7 in. thick; this was formerly mined and burnt for making alum and sulphuric acid. 'Vitriol Works' are shown on the first edition of the Ordnance six-inch map (Warwick 5 N.E.) to the N.E. of Wilnecote Station, but they were abandoned as such more than 20 years ago and the premises are now occupied by Messrs. Skey & Co.

Under this alum-shale lies the valuable bed of fireclay, averaging slightly less than 3 ft. in thickness, in conjunction with which the Bench Coal is and was worked. The Bench Coal also has been worked out over the southern part of the royalty and is mined now from the new Beauchamp Pits only.[1]

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[1] The information additional to what is shown on the deposited plans has been supplied by Mr. I. Bailey, the General Manager, and by Mr. John Cooke, the Mine Manager.

The Park Royalty.

To the north of the workings last described, but separated from them by a fault of about 100 ft. throw, are the old Park Collieries, at which, according to information obtained many years ago by Howell,[1] both the Seven Feet and the Bench were worked. The Seven Feet was mined to the western boundary-fault shown on the map. An old shaft, just east of the railway and a little north of this 100-ft. fault, was recently uncovered and plumbed; the depth to the base, probably the Seven Feet Coal, is said to have been about 100 ft. Howell gives the depth to the Bench as more than 100 yards, but there are many pits and it is not possible to say to which this statement refers. The pits were closed down in his time and no plans are known to exist.

AREA SOUTH OF THE WATLING STREET.

To the south of the Watling Street we enter the area where the Rider is worked. A 'Four Foot Seam' is also worked, but it is now certain that the Rider and the 'Four Foot' are the same. The true Four Foot lies higher up and is not usually identified in this part of the district. The term 'Rider' is applied to a seam that lies not far above or overrides some known coal. The seam specially known as the Rider overrides the Slate Coal, being separated from it by only a few feet in the area further south where the higher seams are better known.

Tame Valley Colliery.

(For shaft-section, see p. 264 and Plate).

In Messrs. Skey and Co's royalty south of the Watling Street and toward the west side of the field are the Tame Valley shafts and from them two seams, the Rider and the Seven Feet, are now worked. The section of the Rider Seam near the shaft shows coal 1½ ft., bat (varies) 1 ft., coal 2 ft. The coals thicken considerably to the east. The upper coal is a first-class house-coal; the lower is a good coal, but softer.

The Seven Feet is about 6 ft. thick, but of this only 4½ are taken near the shaft. The measurement of 9 ft. given in the shaft-section includes the overlying Thin Coal which is here about 1½ ft. thick and a fairly good coal but very gassy and not taken. The Scorps (p. 30) is also left; it consists of a mixture of black and pale coal in streaks, mixed with some brownish material, and though it burns freely it forms a very fine ash which readily blows out of the fire.

At the point where the beds begin to rise rapidly westward toward the margin of the coalfield a heading was driven westward and the Double Coal was cut at a depth of 66 ft. below the Seven Feet. In this heading it was worked to some extent, but apparently in no other part of the mine. The section where worked shows:—

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[1] 'The North Warwickshire Coalfield' (*Mem. Geol. Survey*), 1859, p. 24.

		Ft.	In.
Dark shale roof		0	0
Bakehouse Seam	Coal	2	0
	Black soft bat	0	6
	Coal	2	0
Clay		9	0
Coal		2	6

These rest on the White Clay which is mined at the Wilnecote Tile Works (p. 269). The White Ironstone, below the Smithy Coal, was worked here but was abandoned some years ago.

To the west of the modern royalty a number of old shafts can still be traced close to or on the west side of the railway. There are apparently no plans of these, but Howell refers to the one situated at the angle of the railway and the lane, where the Seven Feet is said to have been worked at a depth of 100 yards.[1] The chief point of interest is his statement that "the level from this pit ran in a direction of Wilnecote Church" and that the "dip was about 20° south of east at an angle of 8°." The line along which the strata rise sharply towards the margin of the coalfield is not parallel to the margin here, as in the ground to the south, but turns into the coalfield and further north is lost.

The Kingsbury Colliery Co's Royalties.

Three royalties in possession of the Kingsbury Colliery Co. are as follows in order from north to south: 1, Hockley Hall. 2, Whateley. 3, Kingsbury. At all three both the Rider and the Seven Feet have been worked.

Hockley Hall.

(For shaft-section, see p. 256; boring, p. 258).

In addition to several minor pits there are four shafts on this royalty. The first is some 100 yards west of the railway; it is now abandoned and is surrounded by a huge shale-tip resulting from the workings in the Smithy Coal and White Ironstone. It was from the bottom of this shaft that the boring was made to prove the beds below the Bench Coal. The second is close to the railway on the west side, while the third and fourth are about 100 yards to the south, on the opposite side of the line. The section of No. 4 shaft is the one given on p. 256.

The Seven Feet and the Rider were worked mainly from the deeper shafts. Both seams are believed to have been cleaned out to the south and west in this royalty, as far as it was safe to go without the risk of the 'old man's' water breaking in. The Rider was 4 ft. thick and the part of the Seven Feet worked was 5 ft. 6 in. thick. A small patch of the Bench was worked about Nos. 2, 3 and 4 shafts, mainly for burning the underlying clay. The section of the seam was bat, 4 in.; coal, 4¾ ft.; pricking, 11 in. The rise of the strata to the west, just under the railway, was 1 in 10.

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[1] 'The Geology of the Warwickshire Coalfield' (*Mem. Geol. Survey*), 1859 p. 25.

Whateley Colliery.

(For shaft-section, see p. 265 and Plate).

The shafts of the Whateley Colliery are situated close to the east side of the railway, about half a mile to the south-east of Dosthill Village. The base of the Rider Coal is about 290 ft. down, and the pit-top is about 255 ft. above Ordnance Datum. The seam near the shaft consists of 3 ft. 2 in. of clean good coal, but it thickens to the south-east. It is in this seam and in this royalty that the great 'dumb-fault' or washout begins that extends to the S.E. into the Kingsbury royalty (p. 37).

The Seven Feet Coal has a thickness of 6 ft. 3 in., but the top 6 in. or 'scorps' is not taken. There is no record of either the Double or Bench coals having been worked here.

Dosthill Colliery.

Before proceeding further south-east to the third of the Kingsbury group of pits, a few notes may be given of the ground to the west of Hockley and Whateley, that is the area on the margin of the coalfield in the neighbourhood of Dosthill.

The workings of the Dosthill Colliery, often known as the Strip and Adit, were situated on the sharp uprise which characterises this margin of the coalfield. At the lane near the railway the dip is 5° or 1 in 12; at 120 yards from the lane, nearer the high road, it is 8° or 1 in 7; close to the shafts it is nearly 30° or 1 in 1·7. It increases still further beyond the limits of the mine, for at 50 yards up the small lane leading into the village a seam of coal was cut open and found to be practically on end.

The Rider and the Seven Feet Coals were worked here and in addition some bands of ironstone above the latter, of which an account is given on pp. 212, 213. At the shafts the depths were 152 ft. to the base of the Rider and 364 ft. to that of the Seven Feet. Of the latter a thickness of 5 ft. 6 in. was actually worked; at the top are the usual 'scorps,' and the persistent Thin Coal, which is not separated here by any parting. So far as can be ascertained the seam was normally developed, but the Rider Coal showed variations possibly due to the proximity of land at Dosthill (p. 42). At the pit it was nearly 4 ft. thick; nearer to Dosthill it was only 27 in.; while at the bend of the lane nearest Whateley it was only 10 in. thick.

Further south there are some old workings near Cliff Cottages, close to a railway-cutting where the beds are on end; some brief notes on these are given by Howell, but all other records of these workings seem to have been lost.

Kingsbury Colliery.

(For shaft-section, see p. 261 and Plate).

Continuing S.E. from Whateley, the Rider and Seven Feet Coals are worked at the Kingsbury Colliery. The former is composed of good clean coal throughout and varies but little in thickness. At Slateley Farm, to the west, it is 4 ft. 11 in.; at New House Farm, to the south-west, 4 ft. 8 in.; and at Hurley Common, to the south-east, 4 ft. 10 in. thick.

As the workings at Hurley are at present the most southerly on this side of the coalfield, a section of the beds associated with the seam may be given here:—

	Ft.	In.
Sandstone	—	
COAL	2	6
Clod	6	0
RIDER COAL (worked)	5	0
Fireclay	0	6
COAL (?BARE)	2	3
Block stone	1	2
COAL	1	0
Fireclay	1	0
Sandstone below not proved.		

It is not clear whether the Bare Coal is represented by the single seam or whether it is here split into two and includes the seam below the block stone.

The point where this section was measured is about 200 yards south of the Methodist Chapel at Hurley Common and a short distance outside the margin of Sheet 154. The base of the Rider is here 758 ft. below sea-level. It is in this seam and in this royalty that the greatest part of the wash-out or dumb-fault occurs that is described on p. 37.

The depth to the base of the Seven Feet Coal at the shaft is 858 ft. At the pit-bottom the part worked measures 5 ft. 3 in. in thickness; to the south-west, at New House Farm it is 5 ft. 4 in. The seam deteriorates in quality to the south and south-east, and the workings near Hurley Common have for the present been stopped. In sinking the shaft a great quantity of water was met with in the Halesowen Sandstones. An account of it has been published by the former manager of the mine, as well as of a curious rock (conglomerate) met with in the Halesowen Sandstones. See pp. 46, 217.

Hall End Colliery, or Birch Coppice No. 2.

(For shaft-section, see p. 251 and Plate).

Eastward of the Tame Valley and Kingsbury Collieries is the southerly extension of Messrs. Morris and Shaw's Birch Coppice royalty. It is worked from two pits on the south side of Watling Street, just outside the eastern margin of Sheet 154. The Rider and Seven Feet are both mined. The former, which is everywhere good and clean, varies in thickness, being about 4 ft. 4 in. at the shaft, thickening to 5 ft. 6 in. southwards. Considerably to the north, at the old No. 1 shaft, it dwindles to 2 ft. 10 in. and has not been worked. Eastward of Hall End it thickens almost to 6 ft., while to the west it thins to 3 ft. 4 in. or much the same as at Whateley. A section of the associated beds near the shaft is as follows:—

Birch Coppice No. 2 shaft.

	Ft.	In.
Rocky bind, with nodules	15	0
Light sandstone	0	6
Rocky bind	1	6
Dark clunch	1	0
RIDER COAL	4	4

	Ft.	In.
Clunch	0	5
Bare Coal ? (not taken)	2	10
Black bat	0	2
Light clunchy fireclay	6	2

The Seven Feet Coal near the shaft is 6 ft. thick. The quality is not so good as at the pit to the north and it deteriorates slightly to the south. The section of the associated beds is given below for comparison with that at Tamworth at the north end of the field. The beds remain fairly constant as a whole; the Seven Feet changes more in quality than thickness and the Thin Coal is never absent in the northern end of the coalfield.

	Ft.	In.
Dark binds	3	0
Dark pricking	0	2
Dark binds with flakes of ironstone containing marine fossils	9	0
Thin Coal	2	3
Soft binds (variable thickness)	2	6
Seven Feet Coal	6	0
Pricking	0	3
Clunchy binds, ironstone balls	I	0
Strong clunchy bind	4	1
Strong bind with ironstone balls	5	3

It may be here noted that the shaft of which the section is given on p. 251 starts a few feet below the Index Spirorbis-Limestone, so that it passes through the lower or sandstone part of the Halesowen Group, the whole of the Etruria Marls, here much mixed with grey measures, and penetrates the Middle Coal Measures to a depth of slightly more than 10 ft. below the Seven Feet Coal.

Dumb-faults or Wash-outs.

The phenomenon of dumb-faults or wash-outs is exceptionally well shown in the North Warwickshire Coalfield. These usually consist of small elongated hollows in which the coal has been washed away and sand or sandy mud deposited. They are least frequent in the Seven Feet Coal which has a marine shale-bed a little above it, and are more common in the Rider, which has a roof containing abundant *Carbonicola*. The fact that the Rider has been more extensively worked than other seams near the old land-surface described on pp. 41, 42 may account for the large number recorded in it, but however that may be it is in the Rider that the greatest dumb-fault so far known has been traced. It commences a little south-east of the pre-Carboniferous land-surface of Dosthill, and widens out in a south-easterly direction. Currents, such as would naturally be set up near the shore, eroded a hollow in the vegetable matter and left sediment in its place. The channel, narrow at first, gradually widened to the south-east till in the Kingsbury royalty it became a mile broad, and before attaining this breadth split into three, leaving two islands in between. The Kingsbury shaft was sunk on to the eastern island, so that there was at first no suspicion of the presence of the wash-out close by. The full details are not likely ever to be known, but the main boundaries in the Kingsbury mine have been kindly supplied by Mr. Tate, the manager, and are shown on the

6-inch geological maps. The erosion did not merely remove the material of the Rider near the margin of the Dosthill land-area, but cut down through the Ell Coal, 51 ft. below the Rider. The depth of the channel must originally have been fully 100 ft.

Another wash-out occurs on the eastern side of the coalfield, in the Nuneaton area, at a considerably lower horizon.[1] In the area north of the Watling Street, where the pre-Carboniferous floor is known to be deepening, the wash-outs are less common, narrower and of less depth, though still occasionally of considerable length. It seems, therefore, that some connection exists between the distribution of the channels and that of the land-areas of Carboniferous times.

FAULTS WITHIN THE COALFIELD.

Faults that lie on the margins of the coalfield or outside it will be dealt with separately; but several have been proved underground within the coalfield, which are not all traceable at the surface. Their distribution is difficult to explain. Along much of the margin of the coalfield the beds are tilted and at times almost vertical, yet faults are comparatively uncommon and of small throw for fully a mile within the field, where the beds are much flatter. The same observation has been made on the opposite side of the field.[2] But in the area of horizontality between, they are more common, some trending roughly north and south, parallel to the length of the field, others roughly N.E. and S.W. The best example of the latter occurs on the south-east corner of Kingsbury Wood, where a fault has a throw of over 120 ft. down S.E., bringing two Spirorbis-Limestones so nearly face to face that they were formerly mistaken for one continuous bed.

Another fault having generally the same trend but a more curving course has been met with at the point where the road crosses the railway to the north-east of Kingsbury Colliery. Here it throws down to the south-east about 10 ft. only; further on it passes approximately under the next road-bridge over the railway, having a throw of 30 ft. Thence it has been followed north-east to a point a little north of Hall End Colliery, a small distance out of the map, on the south side of the Watling Street. The throw has not been tested all along but it seems to lie between 30 and 40 ft. The ground at the surface on the north-west side of it is formed by the top of the big brown sandstone and includes the Spirorbis-Limestone as described on p. 51. A network about Poplars Farm in the south-eastern corner of the map, illustrates the inconstancy of the faults within the field. One has a throw of 57 ft. at one point, but practically dies out not far off to the north; the others do much the same. Not only do the faults change their throw or die out rapidly, but they may range for faults with a reverse throw.

Sometimes small faults occur in great numbers within a narrow belt of ground, the aggregate throw being small. An illustration of this was noted near Fazeley Bridge, when the sides of the Watling Street were cut open.[1] Immediately east of Two Gates the aggregate displacement of a belt of faults, 50 yards wide, was small. Farther east, immediately south of Stonydelph, east of Wilnecote village and on the right bank of a small valley, it causes a deep hollow in the terrace-like outcrop of the thick brown sandstone of the Halesowen Group. Yet there is apparently no displacement of the outcrop as a whole. From this point it gradually comes to lie mainly on the north side of the road again; a little west of the 11th milestone the net throw was 24 ft. down to the north. The belt continues right across the coalfield to the east side, and in the adjacent map (Sheet 155) it is shown by a single line. A similar line, about a mile to the north of the Watling Street, was proved in the Seven Feet workings of the Birch Coppice Colliery, No. 1. A singularity of this belt consists in the fact that many of the component faults range obliquely to the general direction of the belt, an arrangement which suggests a wrench rather than a clean break.

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[1] Summary of Progress for 1912 (*Mem. Geol. Survey*), 1913, p. 23.

[2] The Geology of the Warwickshire Coalfield (*Mem. Geol. Survey*), 1859, p. 15

North of the Glascote Road, of several faults, especially numerous near the eastern edge of the map, the more important range in a north and south direction. They may belong to a belt already mentioned, though none are continuous. One fault stretching from Tamworth Colliery to the outlier of Keuper Sandstone, close to the Glascote Road, has a throw of 42 ft. along the centre of its course, but splits up and dies out beneath the sandstone.

In the area south of the Anker, or more strictly, just south of the canal, a number of east-and-west faults have been met with. Among them may be noticed a tendency to curve so as to maintain parallelism with the boundary-faults which have limited the coal-workings.

An important fault branches off from the western boundary-fault at Fazeley Bridge and with a somewhat curving form passes through the ground between this point and the Glascote Colliery. Near Two Gates it abruptly terminated the workings in the Seven Feet Coal at the south end of the old Park royalty. Here it is believed to have a throw of about 100 ft. Further along its course it was proved in the Caggs Shaft workings to have a downthrow west of about 120 ft. and there are here several faults west of and parallel to it. At Glascote it has been crossed and the coal worked on its western side, the throw still being a little over 100 ft.; a branch fault is given off here that runs into the outer or boundary fault, and where first proved this has a 36 ft. throw also down west. Beyond Glascote, the beds on the downthrow side of the main fault begin to dip rapidly northward, or parallel to the fault, while those on the upthrow side do not, with the result that the displacement of the fault rapidly increases. A further description of the structure is given on pp. 158-160.

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[1] The Geology of the Warwickshire Coalfield, *Mem. Geol. Survey*, 1859, p. 24.

Upper Coal Measures.

ETRURIA MARL GROUP.

General Description.

In the northern part of the Warwickshire Coalfield the Middle or Grey Productive Measures are succeeded upwards by the Etruria Marls. In the original survey of the coalfield the marls were not recognised as a separate group, partly, perhaps, because they were not being worked at the time, but more probably because the chocolate-red marls which form their dominant type are not always recognisable as such on the eastern side of the coalfield. For this reason also the group was not distinguished by colour on the New Series Geological Map, Sheet 155.

Where typically developed the Etruria Marls consist of thick masses of chocolate-red and variegated marls with which are associated some conglomeratic or brecciated bands, generally cemented by carbonate of lime or iron. To somewhat similar bands in the Coalbrookdale district, the name of Espley Rocks was applied by Prestwich.

For some years past these chocolate-red marls have been used for making blue bricks, pipes, etc., and the numerous large excavations provide many opportunities for examining the changes in the character of the beds and the causes which led to them.

Typical Etruria Marl breaks into sharply angular, more or less prismatic lumps. For the most part it is traversed by ramifying cracks or veins along which the colour has been leached out, imparting to the whole a mottled aspect. Bedding is not distinguishable even in the thick bands. A fractured face of the dry marl reveals the presence of many minute pellets of hardened marl, which in this group are rarely calcareous.

The hard bands, useless for brick-making, which intervene between the marls, occur in more than one type, but all are here included under the name Espley Rocks. The most widely spread type of Espley Rock, where quite undecomposed, has a pale or nearly white matrix, composed of a mixture of carbonate of iron and clayey material. The rock readily breaks up into rounded blocks with a more or less deep-brown skin, due to the oxidation of the iron, and this readiness to decompose accounts for its rarely being seen in natural outcrop. Grains of quartz are generally present but are only recognisable in microscopic sections.

Lenticular beds of this type may reach a length of several hundred yards. By a decrease in the amount of clay and an increase in that of iron, the rock passes into sphærosiderite, but in this case the bed is rarely over a foot thick and the lenticle is small, indeed, lenticles may take the form of large nodules arranged in lines.

The coarser beds are formed of clay and carbonate as a matrix enveloping grains of other rocks. Of these, quartz is the most abundant and is generally transparent, as if derived from some igneous or metamorphic rock. Pink and brown jasper is fairly common and with it a hard green substance of very fine texture which may be either fine ash such as occurs in the Charnian Rocks, or green jasper. Similar pink and green grains are common in the higher Carboniferous sandstones described on p. 53. The grains are generally small, and the Espley Rocks of North Warwickshire may be described as sandstones having a large amount of comminuted clay-material and carbonate of iron in their matrix. Large fragments of foreign origin are absent. In a few cases clay or marl occurs as pellets of contemporaneous origin and can be separated by slow digestion in weak hot acid. More common, however, are small fragments of shale, evidently of the same material as that of the shale-chip beds described below.

The Shale-chip Beds is a convenient name for a local variety of the Etruria Marls in which chips or flakes of Cambrian shale abound. The marls assume this littoral character in the neighbourhood of a Carboniferous land-area. At Whateley there are two thick beds almost wholly made up of chips of shale. At Whateley Colliery, situated on the east side of the railway, three miles south of Tamworth, there is a large pit in these marls. An observer looking east from the west side of the quarry sees one of the most characteristic features of the country, in the form of a long steep bank of marls cropping out from below the Halesowen Sandstones, the basal band of which forms the sky line. In the quarry he will find that the upper part of the marl has lost its chocolate colour. West of the railway the marls assume a brighter colour, and are often pinkish or purple. The colouring is more persistent in the lower part of the Etruria Marls than in the upper, and it is to be noticed that the assumption of the normal grey measure type in the marls is accompanied by the development of seams of coal. At the large Dordon pit, a little north of the Watling Street and just east of the area here described, there are two coal-seams developed in grey clays that have replaced the upper part of the red marls. Lenticles of the highly-coloured clays are seen below them, illustrating the persistence of the colour in the lower part.

The continuity of the red marls in the Whateley quarry is interrupted by several bands of harder material of a different colour. The two most striking are green at a depth, but near their outcrop assume a buff-coloured tint which exactly matches that of the Cambrian shales of Dosthill only a few hundred yards to the west. The larger of the two bands is about 6 ft. thick and consists of chips of Cambrian shale, set in a matrix composed mainly of a fine green mud resulting from the final comminution of the shale. The chips, which form at least 95 per cent. of the fragments, are disc-shaped with rounded edges, the flattened form being due to the natural splitting of the shale. There are also present a few larger well-rounded fragments of fine greenish sandstone, possibly also derived from the Cambrian shales, but the igneous rocks of Dosthill were represented by only six rounded fragments among some hundreds of the pebbles. These were much decomposed and it seems likely that the igneous rocks were too rotten near the surface to yield pebbles in pre-Carboniferous times, as they are at the present day. In addition a few small balls of hard ferruginous material were found, one of which had a large crystal of barytes in the centre, while the others were cemented by barytes and impure igneous material. The freshness and form of the larger flakes of shale in this bed and their comparative freedom from interstitial mud shows that the material cannot have travelled far. Judged both by character and position it was clearly a water-sorted scree from the cliffs of the Dosthill island. They prove also that the island was not submerged till nearly the close of the deposition of the Etruria Marls, and we have reason to believe that during the deposition of the Middle Coal Measures it must have projected at least 1,000 ft. above the general level (p. 29).

There are other bands also in which small chips of Cambrian shale occur; one at a slightly higher horizon is green, but more often the chips are stained red and set in a red marl matrix. Fragments half an inch or more in length, however, still show the green or buff colour on cross fracture. An example of this type is well shown in the north-western part of the quarry, especially in dry weather when the shrinkage of the matrix sets free the shale fragments.

In a few cases the Cambrian material appears to have been completely weathered and to have attained the buff colour that it shows at the outcrop. At the foot of the eastern working-face there was, in 1911, a band of sandy and distinctly bedded material, in which all the chips were buff-coloured. In this there are a few fragments of carbonised vegetable remains. Another band, which occurs a little above the 6-ft. green bed, is grey when unweathered and apparently made of completely comminuted decomposed Cambrian shale. It is almost identical with the grey material that further north, at Glascote, is interbanded with the red marls, and on the eastern side of the coalfield almost entirely replaces them.

One of the white Espley Rocks, having a white matrix when first cut open, but weathering into rounded brown blocks, as described on p. 40, occurs at the southern foot of the quarry some distance below the 6-ft. green bed.

Local Details.

South of Whateley.—Immediately south of the Whateley pit the railway passes through an overgrown cutting in the red Etruria Marls. At the base of the group may be seen a typical Espley Rock, rising sharply in the west bank at angles of 40° to 50°. The under side of the rock is clearly exposed and shows perfectly the rounded forms produced by weathering and the deep brown skin. Large blocks when broken show a nearly white interior, in which are embedded numerous small quartz-grains associated with small pellets of white clay and fragments of what are possibly decomposed Cambrian shale. This outcrop not only shows well the characters of an Espley Rock, but also the abruptness with which grey measures were succeeded by red marls.

A little to the south-east, in a large excavation at the Cliff Brickworks, chips of the Cambrian shales are still abundant, but they are here distinctly smaller and the total thickness of the beds in which they occur is considerably less. Further south the outcrop of the marls narrows and is eventually cut out by the great fault shown on the map. The outcrop is almost entirely concealed by overwash, but an old pit between the small stream and the railway marks its position.

About a mile east of the Cliff Brickworks is the Kingsbury Colliery shaft where the whole of the Etruria Marls were penetrated and proved to be about 180 ft. thick. Being more distant from Dosthill than the Cliff Brickworks, the amount of Cambrian shale debris has further diminished, for though no specimens from the shaft were available, the section given on p. 261 shows that red marl was the dominant rock. Still further east, near the middle of the coalfield, the group was again passed through in a new shaft at Woodend. Here the beds were mainly of the normal red or chocolate type; such chips as occurred were small and confined to a few thin bands (p. 254).

North of Whateley Pit.—On the west side of the railway there are several old pits, of no great depth, in the lower part of the Etruria Group. This part shows on the whole a brighter colour than the mass of the group and it contains also some of the greyer bands, which form high-class clays. At the Tame Valley colliery is another of the large pits. The marl here is veined in all directions with paler and sometimes green material, which imparts a mottled aspect to the whole. At the base of the quarry, at the time of the survey, a six-inch seam of coal was exposed, clearly one of those so often recorded in this position in the northern part of the coalfield. Two long wedges of typical Espley Rocks with white matrix were also visible. The higher beds of the group were formerly worked in a pit to the south-east on the opposite side of the Hockley Lane, and here small green chips are easily seen in some bands in dry weather, but both in abundance and size a still further diminution is observable.

Wilnecote.—No good exposures occur for some distance to the north till Wilnecote is reached, where a large pit was formerly worked by the roadside. Though much obscured the section shows that there is more variation in colour than to the south; fragments of Espley Rock and loose ferruginous nodules are scattered about. Numbers of minute shale-chips are strewn around, having been freed by the wind from their muddy matrix.

About 150 yards north of the church a pit is now being worked. Here several dark-grey bands alternate with the red, and one of a specially dark tint is worked for terra-cotta, the clay being sent by train to the works at Loughborough. A well, 80 ft. deep, has been sunk at the bottom of the pit, almost entirely in red marl.

Glascote.—The next good exposure farther north is a large pit on the north side of the Glascote Road, at Messrs. Gibbs and Canning's Pottery Works. The alternation of red marl with grey clay is well shown and illustrates the first stage of the change from the normal type of Etruria Marl to the grey type which prevails on the eastern side of the coalfield. Good specimens of sphærosiderite in nodules may be obtained here. A little further north some new excavations were being made in purple and mottled red marls, showing further stages in the change of colour. There are several old pits here, and one of them is used as the reservoir for the Tamworth Water Supply. One of the grey marls is worked. In this area the group is distinctly thinner than at Whateley.

Amington Colliery.—In a small brickfield close to Amington Colliery the clay at the surface has largely lost its red colour by leaching, but in a small fresh excavation it shows the red tint, though not so strongly as in the area further south. The clays include two thin lenticular beds of Espley Rock, one of which shows larger grains of quartz and other foreign material than usual. The shaft passed through 140 ft. of beds belonging to the Etruria Marl Group, and the details given in the section on p. 244 show how much the red marl is replaced by beds more closely resembling the grey measures. As the pit-top is only a short distance from the base of the overlying Halesowen Sandstones the total thickness of the Group cannot be more than 160 ft., showing that attenuation in the neighbourhood of the old land-area of Dosthill is no less marked than on the eastern side of the coalfield, around Charnworth and elsewhere. Some small seams of coal were proved in the Etruria Marls in this shaft.

Some 600 yards north of Amington Colliery and a little south of the canal is an old brickfield in Etruria Marls, which so closely resemble the ordinary Coal Measures that their true age might not be suspected. At the top of the pit, or rather quarry, is a bed of sandstone with an Espley Rock at its base. The shale or clay beneath is of ordinary Coal Measure aspect and rests upon a seam of coal one foot thick. The beds lower down are mainly shales (clays) and thin, flaggy sandstone, but some red marl occurs on the flat ground at the foot of the steep slope.

In the clay-pit at Tamworth Colliery the Etruria Marls show rapid alternations of grey and variegated clays, but not often the typical chocolate-coloured marl. This pit is close to the eastern side of the coalfield and as the outcrop passes southward along this side the Etruria Marls as a group cease to be distinguishable from the grey measures at the surface and are probably often quite thin.

HALESOWEN GROUP.

A series of normal sandstones and grey marls to which the name Halesowen Group has been given follows the Etruria Marls. The lower part (*a*) consists mainly of sandstones, the upper (*b*) mainly of grey marl; with the latter are associated a subordinate amount of sandstone, fireclay and shale, together with two bands of Spirorbis-limestone, the lower and more persistent of which is known as the Index-limestone.

In an account of the Carboniferous rocks of the Birmingham district, published in 1898, Prof. Lapworth,[1] confining to the lower part the name Halesowen Sandstone, distinguished the upper part as the Spirorbis-limestone Group, owing to the occurrence of these limestones in it. The name, however, is not distinctive, as similar limestones occur in the overlying Keele Group at three or more horizons; the name Halesowen has therefore been extended to cover both sub-divisions of the grey group.

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[1] 'Sketch of the Geology of the Birmingham District.' *Proc. Geol. Assoc.*, vol. xv, 1898, p. 366.

(*a*) *Sandstone Division.*—The sandstones of the lower division are of a yellowish-brown colour on a fractured face, the tint being generally paler in the lower beds and darker brown in the upper. In a weathered surface the rock is incoherent, and the iron-oxide is almost leached out. The large amount of clay-material present gives the rock a dirty aspect and facilitates decomposition.

Unweathered specimens obtained from a new shaft at Woodend were pale-grey or white, hard, and at first sight presented little resemblance to the weathered material. Nevertheless, they also contained much clay-material which served to mask the green or pink colour of the sand-grains. On exposure the large blocks rapidly softened. The pale material has probably been derived from the same source as the pale marls of this group; in the northern area the interstitial matter recalls the minute fragments of Cambrian shale described on p. 41 as occurring in the Etruria Marls, but the large amount of carbonate of iron accompanying it suggests that some may have been derived from igneous rocks.

The appearance of the lower sandstones when thoroughly decomposed is well seen about Wilnecote, especially on the sides of the road leading south to Hockley. The partly decomposed phase is shown by the sandstone that rests upon the Etruria Marl in the pit by the roadside at the Glascote terra cotta works; the clay-matrix exceeds the sand-grains in total bulk.

A little above the middle of the sandstone-division there is a persistent belt of marls of variable thickness, mostly of the grey type but containing a little red marl. In a number of small old marl-pits, mostly used now as ponds, small nodules of Spirorbis-limestone may be observed in these beds.

Above this belt the sandstones tend to run together and form a persistent bed of variable thickness. The rock is harder, less impure and browner than the lower beds, and has been locally called the Big Brown Sandstone. It forms a recognisable feature at the outcrop and with the Index-limestone above it has proved a useful guide in the mapping.

Most of the sandstones of the Halesowen Group contain flakes of clastic white mica, usually of a larger size than those in other parts of the Coal Measures. Fragments of vegetable matter are abundant, and vary from comminuted carbonised particles, occasionally aggregated to form a continuous band, to fairly large fragments of stems or trunks, of which, however, only the outer carbonised skin is preserved. These fragments are common in the brown sandstone, and a fair number were found when sinking through that rock at the Woodend shaft. The Halesowen Group, nevertheless, contains no seams of coal in North Warwickshire. The Woodend shaft (p. 252 and Plate[1]) traversed it and met with only four thin bands of carbonaceous material. Of these, three consisted of a mixture of hardened sand or mud, mixed with finely detrital carbonised vegetable matter; the fourth and thickest had a film of bright coal in it, but including this was only about 3 in. thick.

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[1] In the Plate the base of the group is shown by error at a depth of 317 ft. 10 in. The actual depth is 530 ft. 5 in. (p. 254).

The whole of the sandstones were passed through in sinking the shaft at Kingsbury Colliery, and among them (p. 261) was a bed described as a 'limestone-conglomerate.' From enquiries at the colliery this seems to have been a sandstone containing rather large, as well as small, rounded fragments of limestone. Although no specimens of the whole rock have been preserved, Mr. C. Fox-Strangways obtained some of the pebbles, and a microscopic section (E 2790) of one of these disclosed specimens of Spirorbis. A similar rock is visible *in situ* at the north end of the siding-cuttings of the Hall End Colliery (Sheet 155), situated on the south side of the Watling Street.

The total thickness of the sandstone-division has been proved in three shafts; toward the south of the area, at Kingsbury Colliery, it is 210 ft.; close to the Watling Street it is 175 ft., while at the old Cockspur Pit (Birch Coppice No. 1) it is 205 ft.

For an account of the water in these sandstones, *see* pp. 217, 263.

(*b*) *Shale Division.*—The grey marls which are the dominant constituent of the upper division of the Halesowen Group possess a faintly greenish tinge, varying from pale greenish-grey to pale greenish-brown, but the tinge is rarely seen in the outcrop rock. Sandstones occur locally but form a subordinate part of the whole. There is one horizon just above the Index-limestone at which sandy material is always present; the more persistent part consists of thin flags which often pass up to more solid sandstone and produce a recognisable feature.

The occurrence of Spirorbis-limestones is one of the most notable features in these marls. The band which is distinguished under the name of the Index-limestone is persistent and affords a measure or 'index' to the depth of the workable coals wherever it is recognised. A second bed near the top of the marls has been worked for considerable distances, and, in addition, lines of nodules, scattered nodules and small lenticles have been met with at various horizons.

The grey marls of the Halesowen Group have rarely been used for making bricks or pottery, for some reason which has not been ascertained.

The various bands which compose the Shale Division (*b*) occur as follows in descending order:—

5. Alternating red and grey marls, with locally a few wedges of sandstone, passing down to marls mostly grey. Toward the base is a thin band of hard sandstone, so calcareous as to be almost a siliceous limestone.

4. The higher bed of Spirorbis-limestone.

3. Grey marls resting on a persistent bed or beds of sandy material. The sandy material where best developed is fully 20 ft. thick and consists of fairly solid sandstone passing down to flaggy sandstone. The sandstone becomes thin and soft locally,

but the flags are rarely if ever absent. They are underlain by some grey marl resting on a persistent thin bed of brown shaly marl which immediately overlies the Index-limestone.

2. The Index-limestone.

1. Grey marl, with occasional seams of reddish marl. The thickness varies from 30 ft. to a foot or two, according to the development of the Big Brown Sandstone of the lower division of the Halesowen Group.

The total thickness of the division seems to be about 180 ft., but it varies partly for the reason just mentioned, and partly because the upper beds have been eroded wherever a thick sandstone occurs at the base of the overlying Keele Group.

The greater part of the main outcrop of the Halesowen Group is occupied by the sandstones of the lower division, the basal band generally forming a well-marked escarpment overlooking the softer Etruria Marls. Indeed, between Whateley and Wilnecote this is one of the best marked physical features in the district.

The highest bed, the Brown Sandstone, sends out an easterly spur about Freasley that divides the outcrop of the upper or marly division into two parts. The more southerly spur circles round the foot of the Keele escarpment in a belt of varying breadth, and in this the whole of the beds are present. A second outcrop lies near and to the north of the Watling Street, but in this the higher Spirorbis-limestone and beds above have been denuded.

Another outcrop of the Halesowen Group lies between the two branches of the Western Boundary Fault that stretch northward through Glascote and Amington toward Statfold. The base of the group comes on at a little north of the Glascote road and the sandstones continue to the Anker, what may be their top being exposed in the river-bed. The upper division is quite obscured; owing doubtless to their softer nature these marls have been eroded and have been overspread by river deposits. Their presence has been proved solely by trial borings and small openings made to test the position of the faults.

The Spirorbis-limestones.

As limestones containing *Spirorbis* have been met with at several horizons in the Upper Carboniferous Rocks of this area, it will save repetition to give here a general account of them and of some variations in them which appear to be connected with their mode of origin.

The typical rock is a fine-grained compact limestone varying in tint from dark-grey to light blue-grey, weathering to a buff colour. In a few cases one of the locally persistent bands is cream-coloured or white. Many of the limestones have a brecciated or fragmental aspect which is best seen on a polished surface.

The first stage in the building up of all the beds and larger lenticles seems to have been the evaporation of lime-charged water in shallow hollows, and the deposition of a thin bed of purely calcareous mud which cracked on drying. At a subsequent stage, illustrated only by the purest, most persistent bands, the hollow was again invaded and another layer of lime deposited over the first, filling up the cracks in it. This process was repeated again and again till the limestone might attain a thickness of two or three feet. When the deposition of lime ceased and that of marl resumed, the cracks were filled with marl, and it is a feature in most of the pure limestones that their upper surface is penetrated by threads of marl. The limestones often contain as much as 95 per cent. of carbonate of lime.[1] In some cases the lime filling the cracks has taken the form of crystalline calcite, thus emphasising the breccia-structure.

Another phase of these limestones is seen when the water invading the area after a film has been formed and cracked, has entered with sufficient force to shift and even roll the fragments. This has resulted in the sweeping away of all but small patches in one place and in the heaping-up of the rounded fragments in another. An example of this is seen in a railway-cutting on the Kingsbury mineral line, to the east of the bridge on the Freasley Road. Here the whole bed is built up of more or less rounded fragments of typical limestone in a variable matrix. In the lower part the matrix is mainly calcareous and mostly in the form of crystalline calcite, but toward the upper part it contains much sand and in places fragments of contemporaneously eroded marl. South-westwards the band thins away, but the horizon at which it should occur is exposed in a large brick pit close to the road at the foot of Edge Hill. Here it is represented by small, thin lenticles, which appear to be remnants of the bed from which the heaped-up fragments further north were derived.

The extreme type is a limestone-conglomerate rather than a limestone. The matrix of slightly calcareous mud or sandy mud envelops rounded fragments completely removed from the place of original deposition. From this phase we pass to that of a sandstone containing well-worn fragments as pebbles, generally at its base.

It should be understood that the annelid *Spirorbis* from which these limestones take their name is by no means common in this area, but the Index-limestone usually yields a few. A fracture-surface shows the external form well, and the interior seems to be always filled with crystalline calcite. In the band near the top of the Halesowen Group the fossil is rarer. It is fairly common in the calcite-matrix of the thick band in the railway-cutting mentioned above, but is absent in the included pebbles of limestone. In rare cases a small gasteropod has been found.

So valuable as guides to the structure of the ground are these limestones that much trouble has been expended upon the difficult work of tracing them. The Index-limestone, as already mentioned, lies between the top of the Brown Sandstone and a belt of flags. Its approximate position is thus fixed, but even so digging has often to be resorted to before the bed is located. Old quarries in it can be identified in this area by their great length along the outcrop in proportion to their breadth.

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[1] These limestones were kindly tested by Mr. J. S. Firth, B.Sc.

Local Details.

(*a*) *Sandstone Division.*—In the southern or main outcrop the lowest beds of sandstone are at times exposed at the top of the large quarries in the Etruria Marl at Cliff and Whateley brickworks. A slightly higher bed, exposed in a small opening close to the railway near Slateley Hall, is a friable rock with occasional films rich in clastic white mica associated with abundant grains of carbonised vegetable matter. All the lowest beds, in a weathered and friable condition, are laid open along a lane between Hockley Hall and Whateley. Here there is no marl present, the partings being shaly sandstone, but a little north of the road two small pits have been opened in pale marls locally replacing the more sandy material in the partings.

Close to Wilnecote the characters of the decomposed rock are specially well seen on the road leading southwards to Hockley. Eastward of Wilnecote, about Stonydelph, the highest band below the persistent marl-parting was formerly quarried but the rock has here become quite friable. Near and to the north of Wilnecote marl is more abundant and was at one time used for marling land. With the incoming of marl the escarpment of these beds loses its prominence. As Glascote Heath is approached sandstone again predominates and a bolder feature occurs at the base of the group. The lowest sandstone is exposed in the pit, close to the road, at the Glascote Terra-cotta Works; it is markedly friable and of a pale-brown colour, the clayey interstitial material being considerably in excess of the sand-grains. A slightly higher band makes a long dip-slope, crossed by the mineral railway close by; on the sides of the line the complete decomposition of the sandstone at the surface is well shown. Close to Amington Colliery, where the rock is rather more solid, a quarry has been opened near the winding-engine. Farther north-east the ground is much broken by faults and there is no defined escarpment, but merely a rise in the ground marking the oncoming of the Halesowen Sandstones. In this part of the outcrop the amount of iron in the soft matrix is unusually great. It was probably supplied by the decomposition of the igneous rocks of the old land-surface close by.

The marl-parting that intervenes between the upper and lower parts of the sandstone-division is usually overwashed by sand from the sandstone above. The marl is usually grey and rather hard, but in a few cases some more reddish material is present. The latter may be seen in one of the few pits still open in the angle formed by the Glascote and Alvecote roads, close to the east edge of the road. The marl yields a few small nodules or lenticles of limestone containing *Spirorbis*.

The Brown Sandstone, to which reference was made on p. 45, lies above the marl-parting and makes an almost unbroken feature over considerable areas. At the southern end of the outcrop its character is shown in quarries at New House Farm and Holt Hall Farm, but the best exposure is provided by an old quarry in the angle of the roads at Whateley (Hall). Here the rock is a fairly massive, rather fine-grained, pale-brown sandstone with but little soft interstitial matter. A persistent parting of carbonised vegetable matter, from 1 in. to 3 in. in thickness, occurs near the base of the quarry; it contains many fragments of stems, some of considerable size, internally filled with sand. The bottom-band in the quarry shows a number of cavities and may be a similar rock to the so-called 'Limestone-conglomerate' of the Kingsbury shaft described on p. 46.

There are numerous exposures about the sides of the lanes between Freasley and Ivy House Farm, a clean quarry-face being still exposed a little south-east of the latter. In the long spur to the east of Freasley, the upper part only is seen and the brown colour is not marked, but the darker and more solid lower part is quarried in the corner of a field 350 yards N.E. of Freasley Hall. At Quarry Hill, on the Watling Street east of Wilnecote, the brown tint and hardness are well shown. A series of old quarries on the south side of the Glascote and Atherstone road exhibits the same general brown tint and the local variation in hardness.

In that part of the Amington outcrop which lies nearest to Glascote the lowest beds are evidenced only by a soil of clayey sand with small fragments of sandstone. The higher and more coherent beds come on about the point where the road from Glascote to Amington turns sharply at right angles, and here there are old quarries, a few of which were still open in 1911.

When the Anker is low the top of the sandstone-division is accessible. The rock is white but contains carbonates of iron and lime, and weathers brown. Numerous small clay-pellets occur in the lowest band. Below the sandstones are some sandy shales, locally cemented into small balls by oxide of iron. About 100 yards east of a sharp bend in the river some sandy shales or thin flaggy sandstones occur in the south bank.

(*b*) *The Shale Division.*—The marls which are dominant at the base of this division are rarely visible within the area described, but at about 200 yards north-east of the point where the Spirorbis-limestone outcrop leaves the map, to the north of the Watling Street, there is a fairly large excavation from which material was obtained for making the bricks for the miners' cottages at the Birch Coppice Colliery, No. 1 Pit. This is the only case where these marls have been so used.

The Index-limestone has been traced over a considerably larger area than that shown on the Old Series map of 1855 and has been distinguished from the upper band of limestone, with which it had sometimes been confused. In the south-western part of the outcrop scattered fragments left from the old workings may be seen to the east of Newhouse Farm. By the side of the first fence south of Kingsbury Wood, round an old quarry now filled with water, there lie large blocks of dark-grey limestone, and in the wood there are many old pits, but in all of them the limestone is hidden by talus. The dip is so low that the rock was followed for nearly 100 yards from the outcrop, until the cover reached a thickness of 10 ft. To the north of the wood the workings can still be traced, and near the railway there are circular depressions suggesting that the limestone has been mined.

So far as could be ascertained the bed was never less than 3 ft. thick in this area.

To the north-east of the railway-bridge is a small wood (shown on the map) that has been planted in an old quarry. The limestone, which is still visible in several places, shows the typical buff weathering and yields *Spirorbis*. This is the only good exposure of the rock *in situ* now left. A pond about 100 yards east of the wood shows a deeper working, and from loose specimens of limestone two varieties of *Spirorbis* were found. From this point northward there are no workings beyond the next wood, and in the wood there are only trial-pits, which clearly were failures. A little north-east of the wood is a small pond, which when cleaned out yielded fragments of muddy limestone containing an unusually large number of *Spirorbis*. At Freasley the outcrop is interrupted by a fault, but it recommences beyond another fault, which crosses the railway at Freasley Bridge. It is, however, obscure up to the edge of the map. Immediately to the east the limestone was quarried near Hall End Colliery, while to the south its position is marked by fragments in the banks of a stream.

On the north side of the Watling Street the outcrop was not known previously to the re-survey. It was found as a result of the mapping of the Big Brown Sandstone and the sandy zone of the upper division, and the consequent identification of the belt of ground in which it should occur. It then became clear that some old workings in the narrow wood (The Spinney) close to the Watling Street and east of Quarry Hill were probably in the limestone and a little digging among the debris proved that this surmise was correct. The overlying sandy beds make a good feature further north, and a little below them fragments were again found by digging in the ditches. After a local interruption by small faults the outcrop is again fixed by some long narrow workings to the east of Moorfields Farm, wrongly shown as a road on the map. Two points are worth noting here: firstly, the limestone is more broken up and in the condition of the upper bed as seen in the railway-cutting described on p. 48, and secondly, the pale marl between the limestone and the top of the brown sandstone is thicker than usual; it must be at least 40 ft. thick at one point.

The beds intervening between the two Spirorbis-limestones are completely laid open in the cutting on the Kingsbury branch mineral railway. Commencing at the bridge to the north-east of the colliery, under the arch is a rather flaggy sandstone resting on 4 ft. of hard sandy marl containing a good deal of clastic mica. Under this is some 10 ft. of flaggy sandstone passing to sandy shale, the base of which is level with the rails. A small patch of grey marl which overlies the Index-limestone can be seen in the ditch close by. A little beyond the bridge a small fault (proved in the mine) brings up much more of the grey marl, and probably the limestone itself crops out at the foot of the bank, but is covered with slipped marl. A little farther on to the east the whole of the sandstone comes on and occupies the cutting for some distance, the top passing under the line just before the next bridge is reached. The upper part is soft and decomposed, but the lower is harder, through the presence in it of calcareous material, and has been quarried so that it forms a small crag. A thin marl-parting between the two appears to have protected the lower part from percolation of water and decomposition. The sandstone is succeeded upward in the cutting by grey marls, in which two or three quite thin red bands occur. A little before reaching Freasley Bridge a number of Spirorbis-limestone nodules are seen in the north face of the cutting. One very thin band of fine white calcareous sandstone occurs at the bridge. About 100 yards farther on the upper Spirorbis-limestone crops out on the south side of the line for about 100 yards, its base descending almost to the rail-level. It then rises again and leaves the cutting and the section is continued for some 200 yards in the underlying grey marls. This, the only good section in the district of the grey marls and sandstone, shows how rapidly the marls decompose, though they are fairly hard when met with in a shaft-sinking. In wet weather they gradually pass to almost liquid clay and lead to slipping of the sides of the cutting through the entire length of their outcrop. The sandstone and sandy shale are rather better developed in the cutting than elsewhere.

A quarry opened in the sandstone about 300 yards north-east of Moorfields Farm, shows rock considerably decomposed and at the surface incoherent. Farther east sandy soil marks the outcrop, but the rock is thinner and contains more clay in the matrix, which causes it to weather to small fragments of soft porous sandstone, known locally as 'grousy sandstone.' In spite of its variation, however, this sandstone-horizon can be recognized wherever the beds above the Index-Limestone are present.

That there was another limestone above the Index-limestone was proved by Fox-Strangways in the area to the east (Sheet 155). In the present map its outcrop was found in making a small reservoir just outside the north-east end of Kingsbury Wood. The rock here is grey and occurs more as a series of thin lenticles than a persistent bed. There is an old pit in it on the north edge of the wood, but it does not seem to have been much worked. Of the further outcrop nothing is known till the brickpit on the north side of the road at Edge Hill is reached, where, as already stated (p. 48), it is still in the form of disconnected thin lenticles. Some little distance farther north the pits are larger, and beyond this again is the outcrop in the railway-cutting. A belt of quarries, now planted over, ranges east of Delves Farm, on the edge of the map. The sporadic nature of the workings supports the suggestion made on p. 48 that the bed has been eroded at some spots and the debris piled up at others, where alone it was worth working.

The marls and thin sandstone above the limestone are always overwashed by debris from the Keele Beds, but in the cutting[1] on the mineral line to the Woodend shaft there is a clear section of the highest beds showing a gradual change from red to grey marl, and a perfect passage between the Halesowen and the Keele Groups.

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[1] About 100 yards outside the eastern edge of the map, another good section, or group of sections, of the marls above the higher limestone were exposed when the Kingsbury Rifle Range butts were made. They were still clear in 1911, but are not likely to be permanent.

In the northern outcrop the beds are completely hidden by alluvial deposits and Drift. The pale marls, however, were proved in a boring made by the Amington Colliery Co., the details of which were kindly supplied by Mr. F. A. Grayston. The basal beds of the overlying Keele Marls crop out a little further north, so that the boundary between the two groups can be fixed with reasonable accuracy.

KEELE GROUP.

General Description.

About the north end of the Warwickshire Coalfield the Keele Group consists mainly of red marls and current-bedded sandstones, both calcareous. The marls retain their colour and much of their lime to within a few feet of the surface, but the sandstones become friable through decalcification and vary in tint from a rich red or red-brown to a pale yellowish-brown, according to the amount of iron present. Markedly red-weathering rocks predominate; perfectly fresh specimens of the sandstones are usually purplish or white. The latter, which are more common in the lower portion of the group, may contain as much as 20 per cent. of carbonate of lime, and have somewhat the aspect of siliceous limestones. The lime frequently occurs in fairly large optically continuous sheets, imparting to a fractured face the glistening aspect known as lustre-mottling. The amount of carbonate of iron present is rarely large,

Scattered through most of the specimens examined are many pink and green grains. Similar grains occur in other Carboniferous sandstones, but less abundantly. Easily visible clastic white mica is distinctly rare in most of the Keele sandstones. Fresh specimens of the pale sandstones often contain small specks, and at times threads, of green carbonate of copper; good specimens were obtained during the cutting of sewers both at Kettlebrook and at Amington. Apparently none occurs in the lowest beds, and it is rare at less than 300 ft. above the base of the group.

The sandstones, though their matrix is usually fine-grained, often contain fragments of variable size, at times more than an inch in diameter. These pellets consist mainly of marl, sandy marl, and calcareous material, apparently a form of 'race,' all of local origin. They occur sporadically along certain bands near the base of the beds, but may be met with in any part.[1] In some cases they are crowded together so as to form moderately thick lenticular bands, tending to recur at intervals at the same horizon. Thus a specially thick and coarse pellet-bed has been met with repeatedly above a Spirorbis-limestone in widely separated areas. In places the pellets consist largely of calcareous matter, and the rock contains threads of calcite.

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[1] The pellet-sandstones resemble the conglomeratic cornstones which occur in the Lower Old Red Sandstone, as described in 'The Geology of the Country round Newport', Part 1, South Wales Coalfield, (*Mem. Geol. Survey*), 2nd Ed., 1909, p. 16.

There are so many old pits in this material as to leave little doubt that it was formerly burnt for lime when other sources were few and far removed. A section of a pale-coloured and fresh specimen obtained from the Kettlebrook sewers shows the rock to be markedly calcareous. The matrix is composed mainly of crystalline calcite associated with angular grains of quartz; a few small flakes of white mica are present together with a fair proportion of very fine muddy material. The bulk of the pellets are composed either of sandy marl or of carbonate of iron and lime. The sandy marl consists of minute grains of quartz, minute flakes of white mica and the same muddy material. The carbonate-pellets are so fine in grain that they are almost opaque under a low power; under a high power they are seen to be composed of minute grains of carbonate of iron and lime, the former being usually the more abundant and accounting for their brown weathering. Very small flakes of pale micaceous material are present in considerable numbers and the muddy material occurs in abundant scattered patches. Though rarely spherical, all the pellets have smooth rounded surfaces, resembling those of the nodules of clay-ironstone in the grey Coal Measures, from which, indeed, they differ but little in composition.

To these rocks the term 'pellet-sandstones' has been applied to distinguish them from conglomerates containing true pebbles of foreign material. The pellet-sandstones occur in both the lower and higher part of the Keele Group, but the conglomerates are unknown at a less height than some 900 ft. above the base.

Except for streaks of green material the Keele marls are red. In the lowest beds the tint is commonly chocolate, but higher up it is distinctly redder; at from 300 to 400 ft. up in the group the marls are often of a salmon-pink colour. In places the marls are so calcareous that they were dug for marling the land, being more prized for this purpose than the Triassic marls. On the other hand, the lime in them seems to make them less suitable for brickmaking. Fresh specimens, when hardened and broken across, are seen to contain numerous small oval pellets of marl and calcareous material, the latter often simulating the form of ostracods.

At a height of about 140 ft. up in the group a layer of nodules of limestone, usually yielding *Spirorbis* abundantly, persists at apparently the same horizon over a wide area. Except that it is penetrated by threads of marl the rock is almost a pure limestone, grey in colour. In the vicinity of some of the old marl-pits, at a slightly higher horizon, scattered nodules of Spirorbis-limestone have been met with, but no distinct band or bed. That found by Mr. Cantrill[1] lies at a higher horizon than any part of the group which occurs in the area under description.

Local Details.

There are four separate outcrops of the Keele Group in the Warwickshire area. The first is shown in the south-eastern corner of the map where these beds rest conformably on the Halesowen or Newcastle Group; the second occurs near Tamworth on the south and east side of the Anker and is bounded to the east by a great fault; the third lies to the east of this fault, on the north side of the Anker. The fourth is a small lenticle, between two faults, to the north of Kingsbury.

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[1] 'Spirorbis Limestone in the Permian of the South Staffordshire and Warwickshire Coalfields.' *Geol. Mag.*, 1909, p. 451.

In the first, or south-eastern outcrop, the basal beds of the Keele Group form a fairly bold escarpment overlooking the outcrop of the soft marls of the Halesowen Group. A cutting made through the escarpment for a tramway to the shaft at Woodend shows an alternation of sandstones and marls; the sandstones were freely exposed, and were all white, but the edges of several have become red by the oxidation of the iron and somewhat friable owing to the loss of lime. The marls vary in colour from pale-grey to greenish and red. In the lower beds the paler colours predominate; upwards red becomes more common, and at the top of the cutting all the marls are red. The sandstones are lenticular, and the basal part of the group may be described as consisting of a series of sandstone-wedges of varying lengths set in a mass of chocolate-coloured marl.

One of the sandstones, thicker than the rest, though largely built up of wedges, continues for some distance along the western face of the escarpment forming Edge Hill. The rapidity with which it decomposes is shown in numerous quarries; in several places it has passed into the condition of almost incoherent yellow sand, forming a type of soil that is well seen in the adjacent fields. The base of the bed is a typical pellet-sandstone, of which numerous fragments can be found in old quarries near by. There are many old pits in the marls and excavations for the new sewers near Islington Farm (Woodend) proved the greater part of the flat ground above the escarpment to be underlain by red marl, in which were embedded several small wedges of sandstone, white internally where thickest, but always red outside.

Quite at the edge of the area the pellet-sandstone referred to on p. 53 as occurring a little above a Spirorbis-limestone, forms slightly rising ground. It is better seen a few hundred yards farther south in a quarry which serves to fix its position with reference to the limestone. The limestone is seen as loose fragments in the bank above a little stream and was cut open in making some sewage-works close by. Here also it can be determined that the limestone lies about 140 ft. above the base of the Keele Group.

The lowest beds of the Keele Group were penetrated in the new shaft at Woodend, of which the section is given on pp. 252-256.

In the second, or Tamworth, outcrop the Keele Beds are bounded on the east by the Western Boundary Fault. To the west and north they terminate either at the margin of the alluvium of the Tame and Anker or end off in a bank against which Keuper Sandstone has been deposited.

The strata of this outcrop were identified as Keuper Sandstone at the time of the original survey, but on comparison with the area just described it seemed almost certain that the pellet-sandstones of the Tamworth area must also be of Keele age. Finally the discovery of the underlying Spirorbis-limestone in its proper position placed the matter beyond doubt. Unfortunately there is no permanent exposure, and most of the observations were made during the construction of sewers and the digging of foundations for houses. The dip averages 10°, a rather higher angle than usual, and the strike of the rocks is slightly divergent to the trend of the fault, so that higher beds are brought against the fault in a north-easterly direction. The lowest beds, at the extreme south end of the outcrop, in the bank of the Tame south of Fazeley Bridge, consist of white sandstone, cemented by lime in optically-continuous sheets. The rock weathers rusty-brown, and has a porous aspect. To the north of the bridge the sewers passed through red marls and a thick pellet-sandstone, which proved to be the bed above the Spirorbis-limestone, for numerous fragments of that rock, containing the typical fossil, can be found in the adjacent field to the east. The red marl is frequently exposed in the east bank of the canal, while the sandstone was formerly got for wall-building in a quarry (now completely obscured) on the west side of the road, near the inn, and close to the fault shown on the map. Many excellent examples of pellet-sandstone have been built into the walls hereabouts. The marls were formerly dug for brick-making in a pit situated close to the canal on the east side of Kettlebrook; part of the beds can be examined, and the dip, about 10° to the north-west, is still clear. The section of the beds which were worked is stated to have been as follows:—

	Ft.	In.
Pellet-sandstone, base only seen	3	0
Red sandstone, with white cores	4	0
Deep-red marl	10	0
Calcareous band (said to be limestone) ...	0	4
Marl	5	0
Sandstone	2	0
Marl, base not seen	45	0

The pellet-sandstone, which is exceptionally fresh and calcareous, contains abundant pellets of yellow-weathering calcareous material (race?). No trace of the thin band called limestone could be found, though this part of the section is still clear; it may have been a very calcareous sandstone. The thin sandstone below divides the pit into two parts, forming the floor of the smaller and shallower western part; to the east of this the deeper part of the pit is full of water. During the construction of the sewers at Kettlebrook, deep-red marl was dug through in the main road, but a little to the west a fairly thick bed of sandstone, hard and white, but with a softened outer skin, had to be blasted. In carrying the sewer towards Glascote this rock was encountered in the field south of the new church, and in this field there is an old quarry. The rock has now become quite soft and incoherent, an example of the rapidity with which these Keele sandstones decompose.

In the lower part of the Glascote Road pellet-sandstones were cut open when laying the gas-pipes; they were locally quite sound to within 3 ft. of the surface. Above the canal marls were mostly met with.

A band of Spirorbis-limestone is recorded by Howell[1] at a depth of 30 yards in a well in Glascote village. This appears to have been a deep but unsuccessful well which was sunk in Nevil

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[1] The Geology of the Warwickshire Coalfield (*Mem. Geol. Survey*), 1859, p. 29.

Street, on the south side of the main road. The description of the mode of occurrence of the limestone makes it almost certain that this is the band or line of nodules which occurs about 140 ft. up in the Keele Group, for the overlying pellet-sandstone is brought to the surface no great distance to the north, close to the mineral railway from Glascote Colliery. On the bank of the canal, where this line crosses, a pit was opened in the red marl for tile-making, but the material proved too calcareous for the purpose. Farther up the line, on the north side and near the fault shown on the map, the pellet-sandstone just referred to is visible. Between this railway and the Amington Road some of the best outcrops of the Keele Sandstones are shown. They form four parallel ridges, the rocks in each dipping westwards rather more rapidly than the ground falls. In all four ridges sandstones have been worked to some extent, the lowest and thickest almost continuously. One quarry only remains open, and but a small part of that. The rock has already turned red to reddish-brown, though white cores can easily be found. Most of it occurs in thick wedge-shaped beds, but a small part is in thinner bands, which have remained white except for some reddish patches. Where still quite white the rock is firmly cemented and will apparently break equally well in any direction. The dip reaches 15°–20°, doubtless owing to the proximity of the fault. The pellet-sandstone already referred to seems to form the base of the bed here quarried, for it outcrops a little to the east.

About the Amington Road many pellet-bands have been seen in casual sections, and in cuttings for sewers it was notable that near the surface the sandstones were fairly solid, but that their base was always decomposed, the water from the surface dissolving the calcareous matter only so far as to form a passage for circulation.

The dip observed in the sewer-openings was on the average about 10°, and a similar dip is seen in the old quarry on the north side of the road at about 200 yards west of the canal; the sandstone here has a well-marked pellet-base. The most instructive section laid open by the sewers lay between the alluvium of the Anker and the west end of Amington, on the north side of the main road. Close to the Isolation Hospital and at the edge of the alluvium the cutting first entered the Keuper Sandstone, a pale, gritty rock containing reddish films and locally much white mica. For some distance the Keuper was quite free from pebbles, but at 100 yards above the road it contained a band of large pebbles consisting mainly of quartzite and identical with Bunter-pebbles, except that they were mostly subangular. Among them was also a well-rounded block, 8 in. in diameter, identical with the adjacent Keele Sandstone. Farther on the base of the Keuper Sandstone was exposed, lying on an uneven eroded surface of the Keele Beds, and still farther in the same direction the surface of the latter rises somewhat sharply, making it clear that the one sandstone is banked against the other. The general characters of the Keuper Sandstone left no doubt about its identification; it is, in fact, the commencement of the main mass, of which a detached portion lies on the top of the hill on the south side of the Glascote Road. Before this excavation was made there was nothing to suggest the presence of Keuper Sandstone near the hospital, for though the cover of drift and downwash is thin it completely hides the underlying rock.

The underlying pellet-sandstone occupied the trench for some distance, and from below it, a little below the crest of the hill to the east of the hospital, red marls with thinner sandstones emerge. These dip at an angle of more than 10°, whereas the dip of the Keuper Sandstone is much lower. Farther on toward the base of the hill red marl occupied the trench to a point opposite the inn at Hopleys, and just before reaching this point Spirorbis-limestone was turned out, apparently from a line of nodules. This is not one of the known horizons; it is higher than the bed which lies 140 ft. up on the group, and probably lower than the Whitacre Spirorbis-limestone.[1]

One other exposure of the Keele Beds, in a small pond to the north-east of the farm of Royals, to the south of the Anker shows bright-red marl.

In the area north of the Anker the Keele Beds crop out on the eastern side of the fault already referred to. Close to the farmhouse north-west of the Decoy is a quarry in a thick bed of calcareous pellet-sandstone, suggestive of the bed previously described. In some adjacent fields to the north of the Decoy abundant fragments of Spirorbis-limestone may be found, all of which contain the type fossil in considerable numbers. This association suggests that the limestone is the band which lies some 140 ft. up in the Keele Beds. At the south-western corner of Shuttington House a well and boring were made in these beds to a depth of 165 ft., the section of which is given on p. 226.

Just north of Shuttington House another opportunity occurs of seeing the unconformable superposition of the Keuper Sandstone upon the Keele Beds. To the south-east of the house the bright-red Keele Marls are visible in a pond, but eastwards they are cut off by what is often known as the Eastern Boundary Fault of the coalfield. Close to the line of fault some white sand containing many particles of fresh felspar and constituting a minute patch of Keuper Sandstone, rests on the Keele beds; it is brought on locally by the rocks heeling over into the dislocation.

In the Kingsbury area, in order to prove the position of the boundary fault, the Kingsbury Colliery Co. sank some small trial-shafts close to the first fence south of Thistlewood Brook, 30 yards east of the embankment of the main railway and about a mile north of Kingsbury. One of the rocks passed through was a red calcareous pellet-rock, identical with those occurring in the Tamworth area, and some of the debris from the pit, still available for examination, showed that Keele Beds of typical aspect had been sunk through. The surface gives no indication of the nature of the underlying rocks, but it appears that a small lenticular patch of these beds lies between two faults. The structure is much the same as at Fazeley Bridge, except that the throw of the fault has considerably diminished.

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[1] 'Summary of Progress for 1912' (*Mem. Geol. Survey*), 1913, p. 27.

RELATION OF THE WARWICKSHIRE TO THE LEICESTERSHIRE COALFIELD.

The northern end of the Warwickshire Coalfield is but little more than 5 miles from the point where the coals of the Leicestershire field are being worked from the Netherseal Colliery. It seems likely that the two coalfields formed part of the same basin and that some at least of the seams should be common to both. The most important seam in the lower half of the series in Warwickshire is the Seven Feet and in West Leicestershire the Main. In both areas these are underlain by several seams, two of which at least are workable, while below the lowest coals are the ironstone shales, previously referred to as extending over the whole of the area here described. The identity thus suggested is supported by the fact that both the Seven Feet Seam of Warwickshire and the Main Coal of Leicestershire are associated with shales containing marine fossils. The shale above the Seven Feet is the only marine band at present known in Warwickshire and the Main is the only seam with which any considerable number of marine fossils is associated in Leicestershire.[1]

That the Main coal is locally much thicker than the Seven Feet is probably due to the coming together of two or more seams. It consists of two parts, the lower of which, called the Nether, is probably the real equivalent of the Warwickshire Seven Feet. This correlation of the Seven Feet and the Main coals is strengthened by the occurrence about midway between each of them and the top of the ironstone-shales below, of a seam of cannel coal unlike any of the other coals. It is worked at Amington and Glascote when sufficiently close to the overlying seam to be taken with it.

AREA BETWEEN THE WARWICKSHIRE AND SOUTH STAFFORDSHIRE COALFIELDS.

In this area there are several inliers of Hamstead Beds, the two larger of which were shown on the original one-inch map. They were classed as Permian, their identity with the rocks in Warwickshire at that time classed as Permian, not having escaped notice.

The most easterly and largest of these occurrences occurs near Hints. It begins a little south of the Lichfield Road, near Hopwas, its northern termination being probably a small fault. Thence it stretches in a south-westerly direction to Canwell Gate, a distance of nearly 4 miles. The south-eastern margin of this outcrop is nearly straight, being a fault which throws in the Keuper Marls. The southern termination is also a fault, but the other boundaries are for the most part natural junctions, sinuous and locally interrupted by small dislocations. The Hamstead Beds are followed unconformably by the Hopwas Breccia, described in Chap. vi., but this is impersistent and in its absence they are covered by the Bunter Pebble-Beds. Through much of this outcrop there happens to be no great difference in the dip of the beds in the three groups, though there intervened a great interval of time in which much faulting was effected.

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[1] 'The Geology of the Leicestershire and South Derbyshire Coalfield,' *Mem. Geol. Survey*, 1907, pp. 133-141.

To the north of the Watling Street the outcrop is generally narrow (at Hints Hill it is a little more than 100 yards across), but it widens to nearly 500 yards near Hopwas. In this neighbourhood the sandstones are obscurely exposed in the field south-east of the waterworks, and one of them is the source of water in the well close by, across the fault that terminates the inlier. Bright-red marl, much above the base of the group, can be seen in an old shallow pit on the north side of Hopwas Farm. Just outside the north-west corner of the orchard at this farm a conglomerate built up of lenticles of variable size is to be noted. When fresh the rock contains carbonate of iron and is usually pale-coloured, but at the outcrop it is red, owing to the oxidation of the iron. The more finely grained material is a slightly ferruginous, compact, buff-coloured limestone, free from pebbles and containing threads of crystalline calcite; this component, however, occurs only in small patches. The rather coarser portions consist of calcareous marly sandstone containing pellets mainly, if not entirely, of local material; it is, in fact, a normal pellet-sandstone, such as is described on pp. 53, 54. The coarsest and largest part of the bed is a bright-red, coarse-grained, calcareous sandstone in which, in addition to the pellets, a great number of foreign pebbles are present. Of these sub-angular fragments of a yellowish chert are usually the most abundant. Well-rounded pebbles of a yellowish encrinital limestone are fairly common and tend to occur in groups. Pebbles of fine-grained deep-brown and micaceous sandstone, probably Silurian, are fairly abundant, and pebbles of quartzite and vein-quartz also occur. The lime in the matrix is largely in the form of crystalline calcite. In containing foreign pebbles and in general composition the conglomerate agrees fairly well with the Arley conglomerate of the Warwickshire Coalfield and the Hamstead conglomerate (p. 119) of the South Staffordshire Coalfield, each of which lies at least 900 ft. above the base of the Keele Group. Similar pebbles have been met with 2,000 ft. up in the group, but no conglomerates occur lower down.

To the south-west there is a large overgrown excavation in the marls and sandstones, known as the Devil's Dressing-Room. It appears to have been a marl-pit, but sandstone is said to have been worked as well. A smaller quarry higher up the hill shows sandstone with little lenticles containing small foreign pebbles. The red-brown sandstones crop out in the fields towards Hopwas Hill, and in the fields farther on there are several old pits in the bright-red marl. The best exposures are seen in a lane, near a stream, leading to Hints Hall. On both sides the red sandstones and bright marls can be examined; in the former the iron has been almost extracted from the surface and concentrated in a brown film about an inch or more within the rock. Farther inwards the sandstone is usually of a uniform red tint, but sometimes shows paler patches, or bands of a naturally paler rock, in which the formation of a thin dark film is illustrated even better than in the red beds. At Hints village a fault throws the Pebble-Beds down nearly to the base of the bank on the north side of the stream, leaving only a narrow belt of Hamstead Beds, wholly obscured by downwash.

On the south side of the Bourne Brook the Hamstead Beds have a more extensive outcrop, locally overspread by Breccia, or Pebble Beds. Near the northern end of Weeford Park sub-angular pebbles of chert, set free by the decomposition of one of the conglomerates, are strewn over the ground, and the same observation applies to the fields south-west of the plantation near Brockhurst. About the sides of the ponds at the farmhouse the sandstones and marls are exposed, and a block of Spirorbis-limestone was found about 300 yards south-west of the house. Some of the matrix was still adhering and it was possible to see that the block was angular and had occurred in a contemporaneous conglomerate, such as those described on p. 48. Apparently there must have been a bed of Spirorbis-limestone at a high horizon in the Keele Beds, as in some other parts of Warwickshire.[1] About 500 yards north-west of Canwell Hall is an old pit in which red marl has been worked to a depth of about 10 ft.; below this is a bed of conglomeratic, calcareous sandstone, red, with green mottlings, including 'fish-eyes.' Sub-angular pebbles of yellow and red chert are not uncommon, while quartzite and vein-quartz occur sparingly; one pebble only of crinoidal limestone was found. Fragments of limestone containing cylindrical (tubular) bodies are fairly abundant. They are identical in appearance with Spirorbis-limestone, but *Spirorbis* was not certainly identified.

A little south of this pit a new chapel has been built, the foundations of which passed through a thin skin of Hopwas Breccia and entered Hamstead Beds, here consisting of red marls and sandstone, the latter being in part finely conglomeratic.

Over much of the ground westward of Canwell Gate the Hamstead Beds are covered only by the Hopwas Breccia, so that a small fault, or even the erosion of a shallow valley, may bring them into sight. Two such outcrops occur on the south side of the Canwell Gate fault. In the more easterly of the two an old pit in a plantation a little south of the fault shows both the marl and what appears to be a wedge of sandstone. The second and more westerly is more obscure, but sufficient of the typical marl is seen for the purpose of identification. One of the conglomeratic bands must outcrop at the south end of the inlier, as slabs of it are seen in the fence-side.

An inlier of Hamstead Beds extends from Hilton to the south of Hill Hook. The northern half is bounded entirely by faults, but the boundaries of the southern half are partly natural. Much of the inlier is bordered by arenaceous rocks, over which Keele marls were spread. None of the old marl-pits now give a clear section, but some were open at the time of the first survey of this region. The resemblance to the highest beds of the same series, as seen in Warwickshire, was noted by Howell, and he suggested they might be as much as 2,000 ft. above its base,[2] an estimate that is probably too small rather than too great.

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[1] 'Summary of Progress for 1913' (*Mem. Geol. Survey*), 1914, p. 23.

[2] 'The Geology of the Warwickshire Coalfield' (*Mem. Geol. Surv.*), 1859, p. 33

In Sutton Park, near Streetly, there is another inlier, the boundaries of which are believed to be entirely natural. Though nearly a mile long, the hollow in which the Hamstead Beds appear is shallow. Pinkish marl is exposed at several points in drains, but the margins of the inlier are ill-defined.

On the east side of the high road at Mere Green there is a small outcrop of the Hamstead Beds. Towards its north end an old pit still shows the typical marl, and in a railway-cutting close by a small thickness of the beds is exposed below the Hopwas Breccia.

The best section seen was a temporary one made during the construction of a sewer at Mere Green. Here red marls were interbedded with brownish and greenish sandstones and occasional finely conglomeratic bands with small pebbles of chert and marl-pellets. Much of the marl was fissile and passed imperceptibly into red fine-grained marly sandstone mottled green. It contained numerous casts of sun-cracks and impressions of rain-drops. In some of the coarser sandstones small specks of green carbonate of copper were apparent, as is the case, though in a much lower bed, in the Hamstead Quarry. The resemblance of the strata to the highest beds of Warwickshire 'Permian' was noticed during the original survey.[1] The so-called 'Permian' was estimated to be 2,000 ft. thick, and there can be little doubt that in all these inliers we are dealing with beds high up in that series. In confirmation of this is the evidence afforded by the Little Aston boring[2], which entered the Hamstead Beds at 77 ft. and failed to bottom them at 1,907 ft. From an inspection of the cores it became apparent that the Spirorbis-limestone group was not penetrated and that the boring had not passed out of the conglomeratic series; the base of which is seen in the Hamstead quarries above any beds met with in the colliery shaft.

The strata proved in the boring consist chiefly of marl down to a depth of 911 ft., and below that chiefly of sandstone. Conglomeratic bands occur throughout, but are commonest in the lower division. In them, besides red and yellow cherts, pebbles of reddish quartzite, oolitic and other limestones and Silurian sandstones are abundant. Some of the pebbles are eroded in a manner suggestive of wind-action and they are rarely perfectly rounded.

In the upper part the sandstones are, as a rule, more finely grained and merge gradually into marls, so that many of them could be equally well described as marly sandstone or sandy marl. Occasionally they are mottled with green, and though they closely resemble many Keuper 'skerries' they cannot be mistaken for any beds of the lower part of the series. These upper beds agree closely with the types found at Mere Green, and, taken in conjunction with the Aldridge Colliery exploration,[3] this boring makes it apparent that over the ground north of Sutton the Hamstead Beds are at least 2,000 ft. thick. This would place the workable coals at a minimum depth of 3,500 ft.

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[1] Geology of the Warwickshire Coalfield (*Mem. Geol. Surv.*), 1859, p. 33.

[2] Summary of Progress for 1911 (*Mem. Geol. Surv.*), 1912, pp. 26-27.

[3] F. B. Clark, *Trans. Fed. Inst. Min. Eng.*, vol. xlvii (1913-14), p. 92 (1914).

The Hopwas Breccia, or, in its absence, the Bunter, rests upon a high part of the Hamstead Group. At Shenstone a well passed through what might have been Hopwas Breccia or a conglomerate high up in the Hamstead Beds, between the depths of 143 and 177 ft., and this, combined with other evidence, shows that strata high up in the Hamstead Group occur (below the newer formations) for a considerable distance south of a line drawn from Statfold, in Warwickshire, to Shenstone and Hilton in South Staffordshire. Both on the eastern and western sides of the sunken area which separates the Warwickshire and South Staffordshire Coalfields the Hamstead Beds dip steeply inwards towards that area.

THE KEELE GROUP AT POLESWORTH.

When the mapping of the northern end of the coalfield of North Warwickshire was completed there was still no evidence by which the throw of the north-eastern boundary-fault could be estimated, for Carboniferous rocks were thrown against Trias. The post-Triassic throw can be estimated, for reasons given on p. 161, as being not less than 200 ft., but the throw in the Carboniferous rocks was known to be far greater. The nearest place to the south-east where Carboniferous rocks occur on both sides of the fault is at Polesworth (Sheet 155), and even here this happens in one branch only. To the north-east of the village the coals are worked in the grey measures, which here outcrop at the surface, but are abruptly truncated by the dislocation, which throws in the Keele Beds against them. It was not known, however, to what part of the Keele Group the strata should be assigned.

A re-examination of the ground showed that the Spirorbis-limestone, which lies about 120-140 ft. up in the Keele Group, outcropped in a field by the side of the footpath leading to the waterworks, to the north-west of Berry Warren Hill. It is associated with typical red Keele marls and sandstones, with a 'pellet-sandstone,' which has been referred to as either a conglomerate or a breccia, but includes only fragments due to contemporaneous erosion. A quarry some distance west of the waterworks shows the calcareous sandstones below the limestone. The dip lies between 7° and 8°, and it seemed that the top of the Newcastle or Halesowen grey marl should come to the surface in a hollow farther west near Woodside Farm, just south of the junction of the two branches of the fault. As a fact, an excavation for waterpipes exposed these pale marls for a distance of over 100 yards. The horizon of the Keele Beds at Polesworth and the throw of the faults can therefore be determined here. The results of the re-examination of this ground are shown on the MS. 6-inch maps.

PALÆONTOLOGY.

By J. Pringle.

Perhaps owing to the paucity of clear exposures the Coal Measures of Tamworth have received little attention, and until recently our knowledge of their fossil flora and fauna was insignificant. A local field-club, some years ago, collected fossils from the various spoil-heaps, and many of these are exhibited in the museum of Tamworth Castle. They include plants and freshwater and marine Mollusca, but are insufficiently labelled to be of use. Since the Seven Feet Coal was the principal seam worked it may be supposed that the marine Mollusca were obtained from about this level. The occurrence of a marine horizon above this coal was well known in the district when the re-survey of the area was begun in the year 1910.

Mr. A. R. Horwood, at the meeting of the British Association at Portsmouth in 1911, gave a list of plants and freshwater lamellibranchs from the Coal Measures of the Nuneaton district,[1] but the examination of the fossils of the shales associated with the Seven Feet and Bench coals was not completed.

The chief contribution to our knowledge of the flora and fauna of the coalfield was made in 1912 by Mr. R. D. Vernon.[2] This author publishes long lists of fossils which he obtained during several years of work from the various sub-divisions of the Coal Measures; he gives a brief account of the fauna and directs special attention to the marine horizon above the Seven Feet Coal.

A collection of fossils was made during the progress of the re-survey of the coalfield in 1910 and 1911, and in order to avoid the difficulties which arise from collecting from spoil-heaps on which the shales from the roofs of several coals are mixed, the co-operation of the mine-owners and managers was enlisted. By their kindness truck-loads of the shale associated with each of a number of the seams were kept separate at nearly all the collieries. As a result it was found that the bed containing marine fossils above the Seven Feet coal is of no great thickness, and that it is succeeded by shales in which *Carbonicola* are abundant. In the following lists some specimens presented by Mr. H. Redesdale are included.

Grey Productive Measures.

(*a*) The Fresh or Brackish-Water Fauna and Associated Flora.

It would appear that except for the marine band above the Seven Feet Coal, the whole of the grey productive measures were laid down under fresh or brackish-water conditions. This view has been expressed also by Vernon.[3] *Carbonicola* and other freshwater forms are abundant, and even form 'shell-beds.' The flora also is rich, and fish-remains have been noted in several beds, including the marine band. The numbers which are quoted in the following list of fossils[4] refer to the collieries at which the specimens were obtained, and are as follows:—1, Tamworth; 2, Amington; 3, Glascote; 4, Birch Coppice No. 1; 5, Tame Valley;[1] 6, Whateley.

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[1] Horwood, A. R., 'The Fossil Flora and Fauna of the Midland Coalfields.' *Rep. Brit. Assoc.* for 1911 (1912), p. 105.

[2] Vernon, R. D. 'The Geology and Palæontology of the Warwickshire Coalfield,' *Quart. Journ. Geol. Soc.*, vol. lxviii, 1912, pp. 578-638.

[3] *Op. cit.*, p. 631.

[4] Specimens are registered, J. M. 4792-4824, 4826-4829, 4832-4835, 4837-4849, 4853; Pl. 3708-3712, 3725-3740.

Calamites suckowi *Brongn.*,[2] 1, 6. Roof of Rider Seam.
Cardiocarpus cordai (*Geinitz*), 6. Roof of Rider Seam.
Lepidodendron aculeatum *Sternb.*, 6. Roof of Rider Seam.
Lepidodendron obovatum *Sternb.*, 6. Roof of Rider Seam.
Lycopod macrospores, 6. Roof of Rider Seam.
Neuropteris obliqua (*Brongn.*), 6. Roof of Rider Seam.
Carbonicola aquilina (*J. de C. Sow.*), 1, 4, 6. Roof of Rider Seam and shales above marine bed of Seven Feet Coal.
Carbonicola ovalis ? (*Mart.*) 1, 3, 4. Roof of Little Coal and shales above marine bed of Seven Feet Coal.
Naiadites carinatus ? (*J. de C. Sow.*), 1. Shales above marine bed of Seven Feet Coal.
Naiadites quadratus (*J. de C. Sow.*), 1, 4, 5. Shales above marine bed of Seven Feet Coal.

(*b*) The Marine Fauna.

The marine fossils above the Seven Feet Seam have been detected wherever the coal has been worked. The shale is of a dark bluish-grey colour and contains numerous small nodules of clay-ironstone, in which the fossils are usually well preserved. The fauna is similar to that found in the marine bands elsewhere in the Midlands, but the incursion of the sea appears to have been brief and not to have been repeated in North Warwickshire. Fossil plants are rare, and at several localities the marine shells are followed immediately by brackish or freshwater forms. The numbers which are quoted have the same significance as in the previous list.[3]

Lingula mytiloides *J. Sow*, 1, 3, 4.
Productus sp., 1, 4.
Ctenodonta *cf.* undulata (*Phill.*), 1.
Pterinopecten papyraceus (*J. Sow.*), 1, 4, 5.[4]
Pseudamusium ?, 4.
Euphemus urei (*Flem.*), 1.
Conularia quadrisulcata *J. Sow*, 3.
Conularia sp., 4.
Glyphioceras sp., 1.
Orthoceras *cf.* asciculare *Brown*, 1.
Megalichthys ? [scale], 3.
Rhizodopsis sauroides (*Will.*), 2.

The Red Measures.

The scarceness of fossils in the higher sub-divisions of the Coal Measures is in marked contrast to the productive series, and is not wholly due to the poorness of the sections and the readiness with which the clays disintegrate. Several specimens, however, were obtained from a clay-pit in the Etruria Marls, situated close to the Tamworth Colliery shafts, and these include *Calamites undulatus* Sternb. and *Sphenophyllum marratti* Kidst.[5] *Spirorbis pusillus* (Mart.) has been noted in the several localities where a Spirorbis-limestone is exposed.

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[1] The specimens from Tame Valley were identified in the field, and are not preserved in the Survey Collections.

[2] The specimen from Tamworth Colliery was obtained in disturbed ground, and its precise horizon is unknown.

[3] Specimens are registered, Pl. 3705-3707, 3741-3761, 4755-4756; J. M. 4825, 4829-4831, 4836, 4850-4852, 4854, 4855.

[4] The specimens from Tame Valley were identified in the field, and are not preserved in the Survey Collections.

[5] The specimens are registered Pl. 3713-3724.

CHAPTER V.

CARBONIFEROUS ROCKS, CONTINUED. THE SOUTH STAFFORDSHIRE COALFIELD (CANNOCK CHASE REGION).

By W. GIBSON AND T. C. CANTRILL.

The name Cannock Chase Region may be applied to the whole of the coalfield north of the railway between Walsall and Willenhall, since the order and quality of the coals is practically the same throughout. As in North Warwickshire, the Middle Coal Measures are succeeded upwards by the Etruria, the Halesowen and the Keele Groups; but by far the greater part of the coalfield is occupied by the Middle Coal Measures, and the mutual relations of the other groups are not as clear as in North Warwickshire.

MIDDLE COAL MEASURES.

GENERAL ACCOUNT.

By W. GIBSON.

The Middle Coal Measures form a belt trending north and south with a breadth of about 4 miles in the south, tapering to a point in the north near Brereton. Near Cannock on the west the measures pass unconformably beneath the Bunter formation and continue to do so along a line trending north-east to near Brereton. Here the outcrops are abruptly terminated by the Eastern Boundary Fault which, commencing much to the north (Sheet 140), enters the district a little west of Brereton and forms the eastern boundary of the coalfield along its course through Brownhills to the northern end of the Silurian inlier of Walsall, where the Middle Coal Measures rest directly on the Silurian rocks, though the junction is locally broken by faults. South of Walsall and Willenhall the outcrop passes into the area contained in Sheet 168 (Birmingham) and to the west of Willenhall into the ground in Sheet 153 (Wolverhampton). Farther north it is terminated by the Mitre Fault (p. 98), which brings in Upper Coal Measures on the west up to the point where it passes under the Bunter formation near Cannock.

At the present day the most important mining area lies beneath the Bunter of Cannock Chase. Much of the ground in which mining was formerly more active is thickly covered with drift. A small driftless area occurs about Beaudesert and along the Tame Valley west of Bloxwich; but even here it is difficult to locate the exact horizons exposed, and generally for information about the Coal Measures dependence has of necessity been placed upon mining records.

At the outcrop around Walsall and in pit-shafts between Walsall and Wolverhampton the Coal Measures are immediately underlain by Silurian rocks. To the south again (in Sheet 168) these rocks form the floor to the Coal Measures, with the exception of a limited area around Netherton, where Old Red Sandstone has been recently identified by Mr. W. King. In the central and northern parts of the present area only a few shafts reach the floor. At Hollybank Colliery, certainly, and at Cannock Chase No. 2 Pit, probably, the Coal Measures rest on red sandstones and shales of Old Red Sandstone age (p. 21). At Fair Oak Colliery, farther north, if rocks belonging to the Old Red Sandstone formation are present (p. 24) they were succeeded by the deposition of Carboniferous Limestone, while still farther north, beyond the limits of the map, the Coal Measures repose on Millstone Grit (p. 24).

The slope of the floor of the Carboniferous rocks is to the north-west. Going north it sinks from 500 ft. above O.D. at Daw End, Walsall, to 256 ft. below O.D. at Cannock No. 2 Pit and goes over 300 ft. below at Fair Oak Colliery. The measures below the Deep Coal, it will be observed, also thicken in this direction. Westwards a fall from 404 ft. above O.D. near Walsall Station to 257 ft. below O.D. at Hollybank Colliery takes place, but between Walsall and Hollybank there is scarcely any appreciable thickening of the measures below the Deep Coal. Thus it appears that though the floor to the Carboniferous rocks now slopes fairly uniformly to the north-west, the basin in which the Coal Measures were deposited presented local irregularities of contour.

The lowest beds of the Coal Measures, whether resting on grey Silurian shales or on Old Red Sandstone, contain few or no fragments of these formations. Around Walsall, where grey shales form the bottom beds of the Coal Measures, these are, indeed, scarcely separable by colour and texture from those of the Silurian. But at Hollybank the coarse basal conglomerate of the Coal Measures, in which fragments of Lickey quartzite abound, contains no pebbles of the red sandstones on which it rests. In the records of some of the shafts (Wimblebury) and in borings (No. 2 Cannock Chase and Fair Oak) the presence of red beds containing fireclay, ironstones and thin coals below the lowest seams is not infrequently mentioned. It seems impossible to exclude these from the Coal Measures. Thus the basal beds vary greatly from place to place.

In the absence of rocks of a distinctive type and of fossils representative of a particular horizon the Middle Coal Measures can be most satisfactorily grouped with reference to the position of the main seams of coal:—

	Thickness.	
Etruria Marls.	Ft.	Ins.
Measures	120	0
Essington 3rd Coal (? Old Man's Coal of Cannock)	6	0
Measures	70	0
Essington 5th Coal	2	0
Measures	32	0
Essington 6th Coal (Seven Feet of Hollybank)	7	0

			Thickness. Ft.	Ins.
	Etruria Marls.			
472 feet	Measures ...		57	0
	Robins Coal		5	0
	Measures ...		35	0
	Yard Coal of Wyrley		4	0
	Measures ...		50	0
	Charles Coal of Wyrley		2	0
	Measures ...		30	0
	Brooch Coal (Cannel of Wyrley) ...		4	0
	Measures (including Five Feet and Four Feet Coals of Cannock) ...		40	0
	Eight Feet Coal (Old Park Coal or Main Hard of Cannock, Bottom Coal of Wyrley) ...		8	0
343 feet	Measures ...		50	0
	Four Feet Coal (present but not named over Cannock) ...		4	0
	Measures ...		60	0
	Heathen Coal (present but not named over Cannock) ...		2	0
	Measures ...		60	0
	Stinking or Sulphur Coal ...		2	0
	Measures ...		25	0
	Yard Coal	New Mine Coal, South of Bentley Fault (p. 110) ...	3	0
	Measures		30	0
	Bass Coal		2	0
	Measures ...		55	0
	Cinder Coal (Fireclay Coal of Bentley)		1 to 5	0
	Measures ...		20	0
	Shallow Coal	Bottom Coal of Bentley District ...	9	0
	Measures		10	0
	Deep Coal ...		4 to 6	0
218 feet	Measures ...		42	0
	Coal ...		2	0
	Measures ...		30	0
	Coal ...		3	0
	Measures ...		70	0
	Coal ...		1	0
	Measures (to base of Carboniferous) ...		70	0
			1,033	0

The section is founded on the sequence at Hollybank. Comparing it with sections to the north (Cannock area) and south (Bentley area) a general agreement in the sequence of the seams is observed between the Deep Coal and Eight Feet Coal. Of these seams the Deep and Shallow coals are the most important. None of the coals below the Deep are worked. Going north from Bentley the Shallow and Deep (here an undivided seam) gradually separate until in the north at Cannock No. 2 Pit they are 54 ft. apart. The New Mine Coal similarly splits northward into the Bass and Yard coals. Above the Eight Feet the coals are, generally speaking, impersistent and variously named. In the north, at one place only (East Cannock) is there any opportunity of obtaining the thickness of strata between the Deep Coal and Etruria Marl, where it is 1,030 ft., as compared with 815 ft. at Hollybank. Below the Deep Coal there is a progressive northerly increase of the measures from 218 ft. at Hollybank, 263 ft. at Bentley, 291 ft. at Bloxwich, 426 ft. at No. 2 Cannock Chase.

Within the limits of the map the general rise of the Coal Measures is from west to east up to the Eastern Boundary Fault (p. 161); when the dip suddenly turns over to the east and continues in this direction as far as has been proved underground. The simplicity of the structure is, however, broken by numerous faults, frequently of considerable magnitude but generally of limited extension. They appertain to two systems, one trending north-north-east and the other nearly due east-and-west. The coalfield is thus parcelled out into a number of large blocks; and these again, as is well shown at Brownhills, into smaller blocks by minor interlacing faults. Of the strike-faults (*i.e.*, those having a northerly trend) the aggregate downthrow is to the east, which

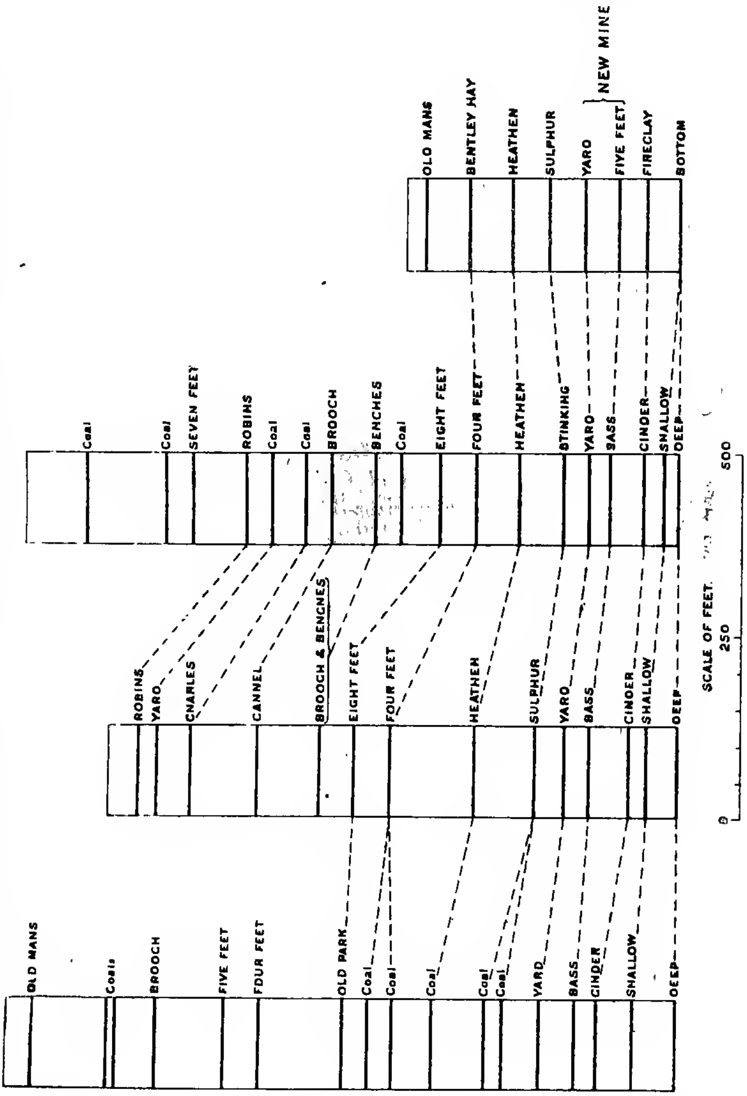

FIG. 2.—*Comparative Sections of the Middle Coal Measures of South Staffordshire.*

counteracts the rise of the measures in this direction so as to give the Coal Measures a broad outcrop and even to keep the chief coal-seams at approximately the same depths over considerable areas.

The relative age of the two systems remains uncertain, but that the major part of both the faulting and the folding is of pre-Triassic age is clearly shown in the Hednesford area, where the horizontal and undisturbed Bunter rests on inclined and much-faulted Coal Measures. Along the eastern margin of the coalfield, however, between Rugeley and Cannock Wood, it would appear (p. 164) that the faulting is, in part, of post-Triassic date, for the Trias is affected here, though perhaps not to the same amount, by faults proved in the underlying Coal Measures; but farther south, at Walsall Wood Colliery, a heading driven eastward proves a fault of not less than 300 yards downthrow east in the Coal Measures which does not extend upwards into the overlying Trias. The structure of the Triassic rocks, therefore, gives little if any clue to that of the Carboniferous rocks on which they rest.

The record of fossils from the northern part of the coalfield is most meagre, and insufficient to admit of our forming any inference as to their zonal values. Absence of easily-available sections at the surface is no doubt the main cause of the paucity of information. A few marine shells—goniatites, *Pterinopecten*, *Posidoniella*—have been recorded from an horizon somewhere above the main coals at West Cannock Colliery, and *Carbonicola robusta* has been mentioned as occurring 30 ft. below the Deep Coal in the Wood Pits of the Cannock and Rugeley Colliery.

These fossils have proved of service in the identification of a local stratigraphical sequence in other Midland coalfields, and further research may throw much light on the sequence in the part of Staffordshire here described.

LOCAL DETAILS.

It has been proved by mining that the Coal Measures of the visible coalfield extend eastward towards the Warwickshire coalfield and westward towards that of Coalbrookdale. To bring out these connections the local details are described under two separate headings: (1) Eastern side of the coalfield; (2) Western side of the coalfield. In each case a geographical order from north to south is adopted. In the following description the references to the positions of faults should be taken to imply their underground positions in one or other of the coals, and not their surface positions, as these are usually not determinable owing to the presence of Glacial drift.

EASTERN SIDE OF THE COALFIELD.

By T. C. CANTRILL.

(1). *The Exposed Area.*

Brereton District.—The exposed coalfield first appears near Brereton, where the measures are bordered on the east by the Eastern Boundary Fault and on the north-west by the unconformable base of the Bunter Pebble-Beds. Under this Triassic cover, however, the Coal Measures are known to extend northward for some distance. In the adjacent map (Sheet 140) information on this point has been furnished by several wells and borings.

Two bore-holes have been put down on the Wolseley Hall Estate, 2½ miles west of Rugeley, in search of coal. The first (No. 1) was carried out in 1878-9 by hand-chisel; the second (No. 2) was made in 1901-2 with the diamond drill. They are within 16 yards of each other in the south-west corner of Wolseley Park and 1½ miles due west of the 'church' at Etchinghill.

The two sections agree closely. No. 1 boring[1] proved a thickness of 253 ft. 3 in. of Trias, below which 462 ft. 9½ in. of Coal Measures were penetrated, to a total depth of 716 ft. 0½ in. The section of No. 2 boring[2] shows that a thickness of 252 ft. 10 in. of Trias overlies the Coal Measures, and that the latter consist of the usual grey, blue, and black shales and fireclays with occasional sandstones and ironstone bands. These measures contain the following important coals:—

Wolseley Park No. 2 Boring.

		Thickness.		Depth from surface.	
		Ft.	Ins.	Ft.	Ins.
1.	Coal		6	266	0
2.	Coal	4	3	316	10
	Fireclay parting	1	0		
	Coal		9		
3.	Coal		10	344	0
4.	Coal	5	6	385	8
5.	Coal	3	5	459	1
	Soft fireclay	1	3		
	Coal	1	2		
6.	Coal	1	6	484	0
	Black shale		8		
	Coal	5	0		
7.	Coal	1	3	518	7
8.	Coal		6	564	5
9.	Coal	3	0	615	1
10.	Coal		7	649	4
11.	Coal		11	699	8
12.	Coal	2	8	774	6
	Fireclay		1		
	Coal	1	5		

The identification of the coals proved in the boring remains uncertain. It has been suggested by Messrs. W. F. Clark and J. T. Stobbs that when the Wolseley Park section is compared with West Cannock No. 1 Plant, No. 2 Pit, the following correlation seems reasonable:—

Wolseley Park.		*West Cannock.*
The Coal 2 at 316 ft. 10 in.	is the	Yard Coal.
,, 4 ,, 385 ft. 8 in.	,,	Bass Coal.
,, 5 ,, 459 ft. 1 in.	,,	Cinder Coal.
,, 6 ,, 484 ft.	,,	Shallow Coal.
,, 9 ,, 615 ft. 1 in.	,,	Deep Coal.
,, 10 ,, 649 ft. 4 in.	,,	Little Coal.
,, 12 ,, 774 ft. 6 in.	,,	Main Coal.[3]

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[1] Information from Sir Chas. M. Wolseley, Bart., and Mr. S. L. Thacker, M.E.

[2] W. Gibson, *Ann. Rep. and Trans. North Staff. Field Club*, vol. xxxviii (1903-4), p. 122.

[3] Not the Main Hard or Old Park Coal of West Cannock.

Two miles east-by-north of the Wolseley Park borings two boreholes at the South Staffordshire Waterworks Co.'s pumping station at Brindley Bank (a mile north-west of Rugeley), after passing through 497 ft. of Trias (p. 271), proved 10 ft. of red and blue marls, presumably either Coal Measures or Millstone Grit.

Farther south we have the boring put down some years prior to 1848 on Lord Lichfield's property at the Birches, about a mile south-west of Rugeley, of which the complete section is preserved in one of Jukes' note-books. The following is an abstract:—

The Birches Borehole.

		Thickness. Ft.	Thickness. Ins.	Depth. Ft.	Depth. Ins.
Trias ...	1. Red sandstone and conglomerate, with thin bands of red marl	285	2	285	2
	2. Red sandstone and red marl, with thin bands of white, blue, and dark marl [no pebbles recorded]...	133	2	418	4
Carboniferous...	3. Black and red marl and shale, with several ironstone-bands	126	10	545	2
	4. COAL	1	1	546	3
	5. Fireclay, blue binds, red and white marl, with red, white, and brown sandstones	66	6	612	9

On the first edition of the Horizontal Section[1] Jukes interpreted 1 and 2 as New Red Sandstone (Trias), and 3, 4 and 5 either as 'Permian,' or as beds below the 15th Coal of Brereton. The latter interpretation he regarded as the more probable. In the Memoir[2] he left the question similarly open. In a revised edition of the Horizontal Section, issued in 1865, he doubtfully assigned 2 to the 'Permian' (*i.e.*, Keele Beds), and 3-5 to the Coal Measures. There is now no reason to suppose that any of the beds are Keele (the old 'Permian'); but whether 3-5 are Coal Measures, or Millstone Grit, or both, there is no means of deciding. The boring appears to show that beneath the Trias the productive part of the Coal Measures has been deeply eroded, and that the workable seams of Brereton, among which at least the Shallow is known to crop out beneath the Trias a little to the south-east of the Birches, have not been brought in again either by a northward dip or by northward downthrow; and as Mr. G. M. Cockin has pointed out, the ground proved by the borehole appears to be part of the barren area subsequently revealed by the sinking at Fair Oak No. 1 Colliery.

Still farther to the south-east, but still within Sheet 140, we reach the ground explored by the workings of the Brereton Colliery.[3] A trial-shaft, sunk in a gravel-pit on Redbrook Field, half a mile east of Upper Birches, is said to have reached at 279 ft. a coal that was supposed at the time to be the Shallow; but as this seam is now known to crop out below the Trias 100 yards or more farther south, the coal in question may be a 2-ft. seam known at Brereton to lie 49 to 53 ft. below the Shallow.

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[1] Sheet 23, No. 4 (1853). The figures differ slightly from those given above, owing to an error of transcription.

[2] Ed. 1, 1853, pp. 286–7; ed. 2, 1859, p. 174.

[3] Information supplied by Messrs. Edward Watson, E. G. Sutherland, and G. M. Cockin.

Passing into Sheet 154, we find a shaft by the roadside west of Chetwynd's Coppice. This is the Flaxley Green trial-shaft,[1] which was sunk about 1850 to the base of the Trias, but not further deepened till 1903. The section is given in the Appendix (p. 232). After passing through 208½ ft. of conglomerates and 85 ft. of sandstones, shales and marls, all apparently Trias, the shaft entered Coal Measures and reached at 329 ft. a 3-ft. coal, believed to be the Seventh Coal of Brereton, and a 4-ft. coal (the Eighth, presumably) at 365½ ft. Below this it passed through a westerly upthrow fault, ranging north-and-south, of about 105 ft., which brought up the Yard and Shallow coals to a level nearly opposite the Seventh and Eighth. The shaft was sunk to a total depth of 508½ ft., and reached the Shallow by cross-measure drifts. The Shallow Coal has been worked over the region lying between the shaft and the Upper Birches, and has been found to rise northward at 1 in 3 or 4 till it reaches the base of the Trias. The line of 'wash-out' along which the seam crops out against the Triassic cover ranges north-eastward and keeps parallel with, and about 150 yards north of, Coppice Lane. The Coal Measures are much cut up by small faults, some or most of which appear not to affect the Trias; so that it is not impossible that, north of the outcrop, the Shallow and other coals are thrown in again under the Bunter cover. If they come in again to the north they apparently do not do so till beyond the site of the Birches bore-hole (p. 72), where no evidence of workable coals was obtained. The north-westerly slope of the floor of faulted Coal Measures on which the Trias was deposited is given by its height above O.D. in the shafts and at the surface. On the south the base of the Trias crops out north of Brereton Hayes Wood at the 400-ft. contour. At the 'wash-out' of the Shallow Coal, 1,200 yards to the north-north-west, it was found to be 163 ft. above O.D. This decline of 237 ft. in 3,600 is equivalent to a slope of 1 in 15, or 4°, a figure agreeing with the average dip of the Trias as seen at the surface.

Brereton Colliery.—This, the most northerly colliery on the South Staffordshire coalfield, comprises several sets of shafts sunk along the eastern margin of the property, close to the Eastern Boundary Fault. Taking them in order from north to south, the Coppice Pit, in the north-eastern corner of Chetwynd's Coppice, pierced a considerable but unknown thickness of Trias and reached the 'Yard,' Tenth, or Cinder Coal at 298 ft. From it the Yard, Shallow, and Deep Coals have been extensively worked in a northerly and westerly direction; but since the unfortunate irruption of water[2] from the base of the Trias in 1908 the workings in that direction have been abandoned and the pits dismantled. About 300 yards to the south-south-east the Belfast Pit goes through the Trias and reaches the 'Yard' Coal at 399 ft. Between this pit and the Coppice Pit the measures rise at 1 in 25.

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[1] Jukes, *op. cit.*, ed. 1, p. 286; ed. 2, p. 174. See also Horiz. Sec., Sheet 23, No. 4, on which it is shown as 'The New Pit.' Later particulars will be found in the Home Office Report (Cd. 4290) by Mr. Hugh Johnstone (1908).

[2] Hugh Johnstone, 'Report on an Irruption of Water at Brereton Collieries,' 1908. Home Office Report, Cd. 4290.

The Belfast Pit served as the principal pumping-pit for the northern part of the workings, but has now been dismantled. Neither of it nor of the Coppice Pit are any sections known to be in existence.

South of the Belfast Pit we come to a number of old shafts, scattered along the crest and foot of the Triassic escarpment, by which the higher coals were worked at the first opening of the district. Some of these pits were called the Hayes Colliery, and were still in use in Jukes's time. The Hill Pits,[1] on the ridge 300 yards north-west of the Holly Bush Inn, pierced 189 ft. of Trias, reached the Fifth Coal at 303½ ft., and the Twelfth or Shallow Coal at 490 ft. From the Hill Pits an inclined plane ran down the scarp slope to the road, where, 200 yards east of the Holly Bush, the Middle Pits[2] passed through all the coals, from the First to the Thirteenth or Deep. About 400 yards north-east of the Middle Pits the Old Engine Pit, still used for pumping, is situated immediately west of the boundary fault and a few yards south of the base of the Trias. A section, usually believed to relate to this pit, beginning "red and white gravel, part of the New Red Sandstone, 26 yards 2 ft.," must refer to an old and now unrecognised pit somewhat farther north. The section of the present Old Engine Pit is given in the Appendix (p. 229).

The Brick Kiln Pits, now the principal shafts of the colliery, are situated in the north-eastern corner of Brereton Hayes Wood. The section of No. 1 shaft is given in the Appendix (p. 230). There are three shafts, sunk about 1864, which commence a few yards east of the base of the Trias. No. 1 Shaft reaches the First Coal at 53 ft. and the Thirteenth or Deep at 457½ ft. The 'Yard,' Shallow and Deep Coals are the seams principally worked. The Yard is about 5½ ft. thick, with a shale-parting 4 or 5 in. thick about 2 ft. above its floor. The Fifteenth Coal is said to be poor in quality; the Deep is one of the best house-coals. The Shallow, which is a very regular seam, is made up as follows:—

	Ft.	In.
Shale roof	—	
Coal, inferior, not worked	1	6
Coal, hard, partly worked	1	6
Coal, bright	7	6
Fireclay floor	—	

None of the coals is a coking or gas coal. The workings of the Brereton Colliery extend from near the Birches and Redbrook Field (in Sheet 140) on the north and are advancing southward under Chetwynd's Coppice, Brereton Hayes Wood, and Beaudesert Old Park. The measures undulate very gently, with dips of about 4½ ins. or less in the yard, and are cut up by two sets of faults approximately at right-angles to each other, one set ranging nearly north-and-south, the other east-and-west, with throws ranging up to 200 ft.

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[1] Horiz. Sect., Sheet 23, No. 4.

[2] The Brereton section published by Jukes as *Vert. Sect.*, Sheet 16, No. 1, appears to relate to one of these pits called the Water-Pit as far as the Twelfth Coal, the rest of the section being supplied from pits known then as the Engine Pit and the Garden Pit, the identities of which are now uncertain.

Fair Oak Colliery.—About 1872–8 an attempt was made to reach coal under the Trias between Hednesford and Rugeley, and two pairs of shafts were sunk half a mile east and south-east of Fair Oak Lodge.[1] The north-eastern pair was known as No. 1 Plant; the other, nearly half a mile to the south-west, was No. 2. From the latter, which are said to have proved the Bass, Cinder, Shallow and Deep Coals, and another coal under the Deep, a small area of Shallow Coal was worked, but the operations were abandoned about the year 1884. A smaller area of the Deep Coal also was worked, the seam being described on the Home Office plan as "stony coal," 3 ft. 9 ins. thick. The plan mentions also the "Main Coal," 2 ft. 6 in. to 3 ft. 7 in. thick; but there is nothing to show whether this is the Deep Coal, or the Fifteenth Coal of Brereton and the Main of Cannock and Rugeley Colliery. The dip of the Shallow Coal appears to be S. 40° W. at 1 in 49½.

Greater interest attaches to No. 1 Pit, however, owing to the fact that some beds of Carboniferous Limestone (p. 24) were met with in one of the exploration headings. Below the Trias (p. 136) a thickness of 448 ft. 7½ in. of Coal Measures were pierced by the shaft and a further boring. Below the Coal Measures 104 ft. 2 in. of red and brown sandstones and shales were proved, which may belong to the Lower Coal Measures or to still older formations. The only coals passed through in both shaft and boring were a smutty coal 3 in. thick at the depth of 423 ft. from the surface, and a half-inch coal at 567 ft. 10½ in., so that between No. 2 and No. 1 Plants all the coals proved at the former must either crop out against the base of the Trias or be faulted out.

Moor's Gorse Pumping Station.—About 1895 the South Staffordshire Water Works Co. put down a new shaft at Moor's Gorse, 2 miles north-east of Hednesford and about a mile south-east of Fair Oak Colliery. After the Bunter Pebble-Beds had been penetrated to a depth of 108 ft. a heading was driven, in the Bunter, from the shaft-bottom in the direction of E. 25° S. It traversed faulty ground, and at a distance of 701 yards passed through an upthrow fault into Coal Measures containing a coal identified as the Shallow and dipping east-south-east at 4½ in. in the yard. The heading ended at a distance of 767 yards from the shaft and at about 375 ft. above O.D. (36 ft. higher than the shaft-bottom). The upthrow fault mentioned appears to be the westerly downthrow of 106 yards encountered in the Brereton and also in the Cannock and Rugeley workings. The result of the exploration has been taken to indicate that the Shallow Coal here crops out under the Trias, and is therefore absent in the ground lying immediately to the north-west; but this conclusion does not seem altogether warranted by the evidence obtained.

But the negative results of the attempts to find coal at the Birches and at Fair Oak No. 1 Plant, together with the facts brought to light at Moor's Gorse and in the Shallow Coal workings of the Brereton Colliery south of the Birches, all support the view of the local mining engineers that the area in question contains no workable seams, and that the Triassic rocks rest directly upon a floor of unproductive Lower Coal Measures or older rocks.

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[1] W. Molyneux, *Geol. Mag.*, 1873, p. 16; *Mining Journal*, vol. xlvi, 1876, pp. 792 and 1136; G. M. Cockin, *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 523, Shaft-section, p. 525; and *Trans. Fed. Inst. Min. Eng.*, vol. xli (pt. 3 1911), p. 323. See also Home Office Plan No. 1678, on which, however, no surface-topography is given.

Beaudesert, Cannock Wood, and Rawnsley.—In the northern part of the coalfield the Coal Measures included between the eastern boundary fault and the edge of the Triassic cover are exposed in Brereton Hayes Wood, Beaudesert Old Park, the New Hayes, and also about Rawnsley and Littleworth; but south of these places they are covered with an almost unbroken sheet of gravelly boulder-clay. Wherever exposed, as in the brooks draining Beaudesert Old Park, and in the spoil-banks of the shallow old pits, the measures consist of grey soft shales and sandstones, which give rise to a yellowish clay soil; there is a complete absence of rocks hard enough to quarry for any useful purpose, or to give rise to any noticeable surface-features. These measures appear to be associated with the Old Park Coal, which occupies a higher position in the sequence than all the beds passed through in the Brereton shafts.

In Brereton Hayes and Beaudesert Old Park, coal and ironstone were worked in old days by numerous shallow pits, and several coal-crops are visible, but the identity of the seams has not been cleared up. A coal is visible in a northward-flowing stream near the northern end of Horsepasture Covert, and may be the old Park Coal. Another, about 100 ft. higher in the sequence, can be found in a watercourse forming the western boundary of the same covert at a point 400 yards N. by W. of the Lodge. About 130 ft. still higher in the sequence a better exposed outcrop runs along the northern face of the high ground crowned with the ramparts of Castle Ring; the coal is exposed to a thickness of 4 ft. or 5 ft. at an old level at the top of a swamp 140 yards north of the rampart. These last two outcrops are marked on the old map. Still another outcrop is visible at Cannock Wood, in the road 150 yards south of the Methodist Chapel, where it is covered by a small outlier of Trias; in a north-westward direction it can be traced by old pits toward the Rawnpike Oak at the north-eastern corner of the New Hayes. This coal may lie some 30 ft. lower than the Castle Ring Coal; but in view of the fact that the Deep and Shallow coals below are known to be broken by considerable faults, which cannot be detected at the surface, little confidence can be placed in any attempted correlation of these outcrops. All the small pits near the outcrops had long been abandoned, even in Jukes's time; many date back to the 18th century and earlier, and ironstone from some of them was smelted on the spot with charcoal in mediæval times.[1]

Less than a mile farther south a good section is afforded by a clay-hole at Cannock Chase No. 7 Pit, where red clayey gravel drift, 10 ft. thick, overlies 14 ft. of yellow loamy soft sandstone over 20 ft. of grey shales and clays, below which a coal, dipping north at 10° and said to be the Old Man's Coal, was visible in 1910. A little farther to the north-east the coal appears to have been worked by shallow pits in old times, and an old brick-yard east of the mineral railway shows some shallow openings in shales with ironstones, immediately west of the Eastern Boundary Fault; while the Keuper Marls have been dug a few yards east of the fault. In the railway, west of Red Moor, sandstone is seen overlying shale, and farther to the north-west a deeper cutting exposes coarse sandstone. North-east of Cooper's Lodge the cutting at Rawnsley School shows, at the eastern end, buff shaly sandstones, nearly horizontal. Opposite the school these are faulted against a group of beds consisting, in descending order, of (1) coal-smut; (2) black shales with ironstone, and (3) yellow clays. The last-named, in which a calcareous band or peldon is visible in the northern bank, rise at 6° toward the north-west and pass down into sandstones, which are underlain by shales. A few yards north-east of the school a brick-yard shows what are probably the same sandstones overlying shales.

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[1] G. M. Cookin, 'The Ancient Industries of Cannock Chase,' *Trans. Burton-on-Trent Nat. Hist. and Archæol. Soc.*, vol. v, 1906, p. 126.

About one-third of a mile north-west of the school a coal, said to be the Five-Foot, crops out under a railway-arch close to Cannock Wood House, Rawnsley; but if it is true that a 348 ft. fault separates this ground from the Wood Pits (Cannock and Rugeley Colliery) the coal under the arch is more likely to lie at least 450 ft. above the Old Park Coal, and to be the Old Man's Coal.

South-west of Rawnsley the railway to Littleworth exposes some sandstones, which dip to the west and south-west, with the result that still higher beds would come on in that direction. This westerly dip marks the approach to a syncline in which the red Etruria Marls of Littleworth appear (p. 112).

At Wimblebury what is called the Old Man's Coal crops out at the top of some extensive old clay-pits opened in the fireclay below the coal for the manufacture of buff terra-cotta bricks. Some nodules of ironstone associated with the coal are characterised by remarkable tubular cavities, lined with a white coating, from which the stone is known as the 'grub ironstone'; but this structure appears not to be peculiar to ironstone occurring at this horizon alone.

Wood Pits.—South of Beaudesert Old Park the Wood Pits, belonging to the Cannock and Rugeley Colliery, were sunk in 1866. The present plant, situated at the north-western corner of the New Hayes, consists of four shafts, viz., the Shallow shaft, the Deep shaft, the air-shaft and the pumping-shaft. They commence at an altitude of 675 ft. above O.D. The upcast shaft, after passing through the Old Park Coal at 138 ft. from the surface, and sundry other thin and un-named seams, reached the Sulphur Coal at 336 ft., below which followed the Yard, Bass, etc., with the Deep at 609 ft. The full details are given in the Appendix (p. 235). The Old Park Seam was worked over a small area around the present pits.

The direction of main jointing ranges about north-and-south. The ground is little troubled by faults. One, proved in the Deep Coal to be a downthrow south of 348 ft., ranges east-and-west across the New Hayes; another, supposed to be 300 ft. down west, ranges north-and-south through Rawnsley.

Wimblebury Pits.—The Wimblebury Pits of the Cannock and

Rugeley Colliery are situated in the valley between Wimblebury and Littleworth, and were sunk about 1872. The height of the surface above O.D. is 575 ft. The shafts, of which there are two, commence in beds lying higher in the sequence than any of those pierced by the Cannock Wood Pits. The Old Man's Coal was reached at 60 ft. from the surface; below followed several thin or un-named seams, and the Brooch at 321 ft. The Old Park was passed through at 451 ft., and the Yard, Bass, Cinder, Shallow and Deep in order, the last being 875 ft. from the surface (Appendix, p. 237).

The Old Man's Coal was extensively worked in old days over the Wimblebury area, and about 1898 the clay underlying it was made into firebricks and buff terra-cotta ware (p. 77). The Diamond Ironstones mentioned in the sections showed the following details:—

	Ft.	In.		Ft.	In.
Dark binds	1	3	at	931	7
Ironstone		2		—	
Dark binds	1	0		—	
Ironstone		3		—	
Dark binds	1	4	at	934	4

Cannock Chase District.—South of Cannock Wood and Wimblebury the eastern side of the coalfield is covered with a sheet of gravelly boulder-clay from which the Coal Measures do not become free till we reach the neighbourhood of Pelsall. The surface of the country slopes gently and evenly in the same direction, falling from a height of 787 ft. near Wimblebury to 400 ft. at Walsall.

In the northern part of this drift-covered area our knowledge of the measures is dependent wholly on the evidence of shaft-sections, of which the majority are furnished by the various pits of the Cannock Chase Colliery Company.[1]

Of these the most northerly pit, known as No. 7 Plant, is situated a mile north-north-west of Chase Terrace. The shafts commence at the outcrop of what is said to be the Old Man's Coal (p. 76) at an altitude above O.D. of 637 ft. The following is a list of the coals met with in the upcast shaft:—

Cannock Chase No. 7 Plant.

	Thickness. Ft.	In.	Depth. Ft.	In.
Coal, 6 ft. 0 in. [Old Man's Coal?] ... ... Measures, 9 in.... ... ... Coal, 1 ft. 0 in.	7	9	7	9
Coal (Cannel Coal)		3	16	0
Coal		8	24	10
Coal		7	32	6
Coal	1	0	65	11
Coal	1	6	80	11
Coal	1	0	95	4
Coal	1	0	122	9
Coal (Brooch Coal)	3	9	156	2
Coal, 3 ft. 0 in. Parting, 6 in. (Five-Feet Coal) ... ... Coal, 1 ft. 8 in.	5	2	255	2
Coal (Four-Feet Coal)	?		295	7

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[1] Information supplied by Mr. S. F. Sopwith.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Coal (Old Park Coal)	?		408	0
Coal	1	0	485	7½
Coal	2	5	519	2½
Coal		6¾	546	9½
Coal		6½	550	7½
Coal	2	0	605	6½
Coal	2	9	619	0
Coal, 3 ft. 11 in. Parting, 1 ft. 1 in. Coal, 0 ft. 5½ in.	5	5½	663	11
Coal, 2 ft. 1 in. Parting, 2 in. Coal, 5 ft. 0 in. Parting, 0 ft. 9 in. Coal, 1 ft. 3 in. } Bass Coal	9	3	720	8½
Coal		6	743	5½
Coal, 3 ft. 10¾ in. Parting, 3 ft. 9¼ in. Coal, 2 ft. 7 in. } Cinder Coal	10	3	766	8
Coal (Shallow Coal)	8	4½	786	11
Coal (Deep Coal)	6	10	851	9
Coal (Gubbin Coal)	1	6	878	1
Fireclay and bat		8	878	9

In the district adjacent to these pits the measures are practically flat. South-west of the pits a fault ranges north of west, from the Eastern Boundary Fault, towards Wimblebury, with a downthrow north of 30 yards, increasing westwards to 60 yards. Parallel to it and farther south a fault-trough 30 yards deep ranges under Cuckoo Bank (a little south of the Hollies). These three faults range toward a north-and-south fault with downthrow east of 60 or 70 yards (the Yard Coal being thrown against the Deep). Along the eastern side of this fault the measures dip westward at 13 in. per yard.

West of this fault the shafts at No. 8 Plant of the Cannock Chase Colliery have been sunk half a mile north-east of Five Ways. Commencing at 669 ft. above O.D., the downcast (northern) shaft passed through 38 ft. of Glacial drift before reaching the Coal Measures. The following list gives the principal coals, with thicknesses and depths from the surface:—

Cannock Chase No. 8 Plant.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Coal, 2 ft. 7 in. Parting, 3 in. Coal, 2 ft. 5 in. } Five-Feet Seam	5	3	364	7
Measures	29	2	393	9
Four-Feet Seam	4	4	398	1
Measures	103	9	—	
Old Park Seam	7	0	508	10
Measures	75	1	—	
Coal	2	3	586	2
Measures	92	1	—	
Coal	1	6	679	9
Measures	48	9	—	
Yard Coal	3	4	731	10
Measures	38	2	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Bass Coal ...	8	2	778	2
Measures	30	7	—	
Cinder Coal	3	4	812	1
Measures	7	6	—	
Coal	1	3	820	10
Measures	21	9	—	
Shallow Coal	7	3	849	10
Measures	41	10	—	
Coal	1	2	892	10
Measures	47	0	—	
Coal (?Deep Coal), with a 3 in. bat in middle	3	0	942	10
Fireclay	9	0	951	10
Blue binds, mild	4	6	956	4

Between No. 8 Plant and Wimblebury some large overgrown spoil-heaps mark the site of two shafts known as the Cannel Pits or No. 6 Plant, abandoned in 1874, from which the Cannel Coal was worked under a limited area bounded on the north-west by an 80-yard upthrow. The northern or winding shaft, which commenced at an altitude of 704 ft. above O.D., reached the Cannel at 103 ft. 9 in., the Seven-Feet at 133 ft. 9 in., and a coal at the bottom of the pit at 145 ft. 9 in. The Cannel Coal was won by a cross-measure drift from the Seven-Feet. The works were drained by a pumping-shaft, 100 yards south-east of Dugdale, which reached the Cannel at 82½ ft., the Seven-Feet at 120 ft., and was continued to a total depth of 141 ft. The measures appear to dip to the north-west, and the Cannel is estimated to crop out, beneath the Glacial drift, about 350 yards south-east of the winding-shaft, and seems to have been worked near the crop by a pair of shafts, 23 ft. deep, where pieces of cannel and shale with fish-teeth and scales (*Elonichthys?*)[1] can be seen on the tip.

The Cannel Coal presented the following section:—

Cannel Coal at Cannock Chase No. 6 Plant.

	Ft.	In.
Cannel coal (worked) ...		11
Fireclay...		3
Foot Coal (inferior cannel, not worked) ...		9
Fireclay...	2	0
Coal (not worked) ...	3	0
	6	11

Between the Cannel Pits and Wimblebury Farm there are signs of small old pits at which, to judge by debris in the soil, cannel seems to have been worked, and it is probable that the crop shown on the old map as ranging from Heathy Hays (now Five Ways) to Cooper's Lodge was intended by Jukes (Memoir, ed. ii, p. 102) to represent that of the Cannel Coal.

The shafts at No. 5 Plant of the Cannock Chase Colliery, at Chase Terrace, proved the following section in the downcast (southern) shaft:—

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[1] Staff. 51 SE. W λ 1. T.C.C. 2121–2126.

Cannock Chase No. 5 Plant.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Sand and gravel (Glacial)	58	0	58	0
Blue clay, rock binds, black ground, rock, blue binds with ironstone	45	6	103	6
Coal	1	8	105	2
Measures	24	7	129	9
Coal (Cannel coal)	1	8	131	5
Measures	6	4	137	9
Coal	2	0	139	9
Measures	70	0	209	9
Coal (Stinking Coal)	2	2	211	11
Measures	41	0	252	11
Coal (Yard Coal)	3	10	256	9
Measures	43	6	—	
Coal (Bass Coal)	7	0	307	3
Bat and coal	3	0	310	3
Measures	27	6	—	
Coal	1	0	338	9
Measures	1	0	—	
Coal (Cinder Coal)	2	0	341	9
Measures	1	6	—	
Coal	2	0	345	3
Measures	14	0	—	
Coal (Shallow Coal)	7	4	366	7

The level of the bank-top is 560 ft. 4 in. above O.D.; the ground-level would be a few feet lower. The general dip of the measures adjacent to the shafts is north-west at 3°.

No. 3 Plant is situated about half a mile farther to the south-west, near Norton Bog. Under 41 ft. 10 in. of Glacial drift, and 264 ft. of measures containing four coals ranging from 4 in. to 2 ft. 9 in. in thickness, the following succession was sunk through in the downcast (southern) shaft:—

Cannock Chase No. 3 Plant.

	Thickness.		Depth from surface.	
	Ft.	In.	Ft.	In.
Yard Coal	3	5	309	3
Measures	41	5	350	8
Bass Coal	6	5	357	1
Measures	17	6	—	
Coal		6	375	1
Measures	2	0	377	1
Cinder Coal	2	11	380	0
Measures	22	7	—	
Coal (Sulphur Coal)	1	8	404	3
Measures	18	0	—	
Shallow Coal	7	0	429	3
Measures	45	3	—	
Deep Coal	5	6	480	0
Measures	18	8	—	
Coal	1	6	500	2
Fireclay rock	5	2	—	
Black shale and clod, with 12 in. of ironstone in four bands	6	5	511	9

The surface-level is 533 ft. above O.D. The general dip of the measures near the shaft is north-west at 3°.

Leaving for a while our description of the Cannock Chase Collieries and passing westward, we have at Five Ways the shafts of the Coppice Colliery,[1] sunk in 1892. The shafts were sunk close to several lines of fault, so that the sections are not so reliable as would otherwise be the case. In the downcast, northern, or No. 1 Shaft, a thickness of 50½ ft. of Glacial drift was found to overlie the Coal Measures. The first coal, reached at 76 ft., and supposed to be the Old Man's Coal, is 5 ft. thick. A coal 5 ft. 10 in. thick, with a band of cannel on top, was reached at 113 ft.; below it a coal called the Seven-Feet, 7 ft. 2 in. thick, was reached at 216 ft. 6 in. The Brooch Coal, 4 ft. thick, was 322 ft. 10 in. deep. Below this occur the Five-Feet, sundry unnamed coals, the Yard, and the Deep, the last-named being 846 ft. 10 in. from the surface. In the shaft the Bass, Cinder and Shallow coals appear to be faulted out. Below the Deep Coal, after several thin coals were passed, the shaft ended in coal 2 ft., red marl 5 ft. 7 in., at a depth of 956 ft. 3 in. The top of the pit-bank is 600 ft. above O.D., the ground-level being 8 ft. lower. The Deep Coal consists of roof coal 4 in., black bat 2 to 5 in., bottom coal 5 ft. 4 in. to 5 ft. 8 in. The property is crossed by several north-and-south faults with throws ranging from 12 yards to 36 yards, and by others at right-angles of less magnitude. South-east of the colliery some small old pits on the eastern side of the Five Ways mineral railway, 350 yards E. by N. of Commonside Farm, mark the outcrop (under Glacial drift) shown on the old map as running north-eastward from Norton onto Norton Common; and there are other old pits on the same line at Norton Terrace, 300 yards south of the farm. This coal was locally believed in Jukes's time to be either the Bentley Hay or the Bentley Old Man's (Wyrley Bottom) Coal, but Jukes[1] suggested that it might be the latter. The identification of this outcrop is still more hazardous nowadays, in view of the many faults that have been proved underground since Jukes's time.

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[1] Information supplied by Mr. Chas. Fisher.

A little farther south, at Norton Canes, the Conduit Colliery's shafts proved the following depths (in the upcast or No. 11 pit):—

Conduit Colliery, No. 11 *Shaft.*

		Thickness.		Depth from surface.	
		Ft.	In.	Ft.	In.
Glacial gravel, sand, and clay		55	0	55	0
Yard Coal		3	2	296	2
Coal, 1 ft. 8 in. Bass, 10 in. Coal, 3 ft. 10 in.	Bass Coal	6	4	347	3
Bass			6	—	
Coal			6	348	3
Pricking			3	—	
Coal			3	348	9
Coal, 9 in. Bass, 1 ft. 10 in. Coal, 3 ft. 7 in. Fireclay, 2 ft. 6 in. Coal, 2 ft. 0 in.	Cinder Coal	10	8	377	0
Shallow Coal		6	6	397	4
Coal, 8 in. Clod, 5 in. Coal, 5 ft. 3 in.	Deep Coal	6	4	455	3
To Little Coal at bottom of shaft		—		470	0

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[1] *Op. cit.*, ed. 2, p. 102.

A little farther south, at Norton Green Colliery, the following depths were proved in the downcast (southern) or No. 2 shaft:—

	Thickness.		Depth from surface.	
	Ft.	In.	Ft.	In.
Coal (? Sulphur)	2	6	195	0
Yard Coal	3	0	341	0
Bass Coal (coal 5 ft. 3 in., parting 9 in.) ...	6	0	389	10
Cinder Coal	8	5	422	0
Shallow Coal	5	6	443	6
Deep Coal	5	0	497	6

The Cinder Coal presents the following details:—

	Ft.	In.
Coal		9
Bat	1	2
Coal	3	6
Fireclay	2	0
Coal	1	0
	8	5

The general direction of dip appears to be N. 20° W. at 1 in 17, and the ground is crossed by several faults having a range of S. 20° W.

Crossing now to the eastern margin of the coalfield, we conclude the description of the Cannock Chase Colliery with an account of the shafts at Chasetown. No. 4 Plant, 500 yards N. 20° W. of St. Ann's Church, is now disused. In these shafts a coal 2 ft. 3 in. thick was met with above the Sulphur Coal, and the Deep Coal was found about 360 ft. from the surface. The No. 2 Plant, known as the Uxbridge Pit, at the western end of Church Street, is now the principal pit and the headquarters of the colliery, and appears to be the one that was in use in Jukes's time.[1] The section is of special interest, as it was from the bottom of the upcast (north-western) shaft that sinking and boring was extended in 1866 below the Deep Coal into what were believed to be Silurian strata.[2] The following abstract section, down to the Deep Coal, relates to the downcast shaft; below the Deep Coal the section is taken from the upcast shaft. The base of the Coal Measures was probably passed through at the depth of 787 ft. 1½ in.; the beds below that depth are referred to elsewhere (p. 21).

Cannock Chase No. 2 (Uxbridge) Plant.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Glacial sand and gravel	26	0	26	0
Measures	107	6	133	6
Sulphur Coal	1	1	134	7
Measures	42	3	176	10
Yard Coal	3	6	180	4
Measures	51	0	231	4
Bass Coal	6	0	237	4
Measures	16	10	254	2
Coal		9	254	11

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[1] *Op. cit.*, ed. 2, 1859, p. 171. The Uxbridge Pit appears (from a MS. note by Jukes) to have gone no deeper than the Bass Coal by May 3, 1852.

[2] A. Sopwith, 'The Northern Part of the South Staffordshire Coal-Field,' *Trans. Fed. Inst. Min. Eng.*, vol. iii (1891–2), p. 50.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Black bat	5	8	260	7
Cinder Coal	3	0	263	7
Measures	12	8	276	3
Coal	1	4	277	7
Measures	17	3	294	10
Shallow Coal	6	8	301	6
Binds	54	0	355	6
Deep Coal	5	8	361	2
Fireclay and shale with ironstone (Gubbin and Balls)	16	0	377	2
Coal	2	0	379	2
Fireclay, grit, blue binds, black clod, and ironstone-bands	28	7	407	9
Coal		11	408	8
Fireclay, sandstone, binds, clod and ironstone (Blue Flats)	47	4	456	0
Coal	1	0	457	0
Fireclay, grit, binds, peldon	103	0	560	0
Breccia containing pieces of limestone	3	0	563	0
Grit and binds	15	5	578	5
Breccia containing pieces of limestone	3	3	581	8
Rock, binds, black clod with ironstone, fireclay	116	4	698	0
Coal		1½	698	1½
Rock-binds with fossils; black bat, fireclay, peldon	72	0	770	1½
Rock-conglomerate of hematite-nodules, with green 'clay slate' partings, brown and white grit [beginning of red measures]	17	0	787	1½

With regard to the grouping of the section, all the items down to the thin coal at 698 ft. 1½ in. must be referred to the Carboniferous, and presumably to the Coal Measures, and not to the Millstone Grit; and the same conclusion may be extended through the binds, bat, fireclay, and peldon down to 770 ft. 1½ in. The next item, 17 ft. thick, characterized by red conglomerates of hematite-nodules, is open to doubt. To judge by the record, and in the absence of samples, it may be suggested that if the nodules were not some form of ironstone, they may have been pebbles of red marl, or of other rocks coated with or reddened by iron oxides. In any case, this item seems the most suitable to regard as the base of the Coal Measures.

The general direction of dip hereabouts is north-north-westward; between No. 2 Plant and No. 3 Plant the Deep Coal falls about 117 ft. in 3,150 ft., *i.e.*, at the rate of 1 in 27, or about 2°.

Half-a-mile south of the Uxbridge Pit, the Hammerwich Colliery or Cannock Chase No. 1 Plant was situated immediately east of the dam of the Canal Reservoir and adjacent to the Anglesey Wharf, where the old shafts may still be seen. The following is an abstract of the section[1] of one of the shafts:—

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[1] Vert. Sect., Sheet 16, No. 2. See also Jukes, ed. 2, p. 74, for details of the measures between the Shallow and the Deep Coals.

Hammerwich Colliery.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Black earth, gravel and sand, red clay (Glacial drift)	40	0	40	0
Measures	20	6	60	6
Bass Coal	5	6	66	0
Measures	12	9	78	9
Coal		9	79	6
Measures	18	5	97	11
Coal, 9 in. Metals, 1 ft. 2 in. Coal, 2 ft. 4 in. } Cinder Coal	4	3	102	2
Measures	24	6	126	8
Coal	1	5	128	1
Measures	13	11	142	0
Shallow Coal	7	1	149	1
Measures	49	11	199	0
Coal, 7 in. Clod, 6 in. Coal, 5 ft. 2 in. } Deep Coal	6	3	205	3

The dip appears to have been north-westward at 5°. A southerly downthrow of 39 yards, which leaves the Eastern Boundary Fault at St. Ann's Church and runs westward, is the only fault of any importance met with in this part of the Cannock Chase workings. The boundary-fault itself is described elsewhere (p. 164).

Brownhills.—The south-easterly rise of the measures near Chasetown, and the absence of all the coals above the Bass in the Hammerwich shafts, prepares us to find the lower coals cropping out in succession along the western side of the Boundary Fault as we proceed towards Brownhills. These outcrops were laid down on the old map by Jukes with much precision, presumably from considerations of the depths at which the coals were reached in the shallow pits then working. But in a district in which the measures rise to the surface at such a gentle inclination, and are covered with 30 or 40 ft. of Glacial drift, no actual crop-working by opencast was practicable: the nearest approach to such operations was the sinking of bell-pits. No attempt, therefore, has been made to show these outcrops on Sheet 154; but a brief description will be given of the belt of ground along which the five lowest coals—the Yard, Bass, Cinder, Shallow, and Deep—approach the surface and range south-westward.

The Yard Coal, 180 ft. deep in the Uxbridge Pits, and absent at the Hammerwich Pits, must crop somewhere between the two. Farther south, the numerous shafts of the old Coppice Colliery worked the ground that extends from the canal reservoir, across Brownhills Common, towards Birch Coppice. Over this ground the average direction of dip is north-westward, at 3 to 7 in. in the yard, and the measures are cut by three important lines of fault, which run westward from the Boundary Fault. One, called the Hammerwich Fault, 150 yards south of the reservoir, is a southerly downthrow of 33 yards, decreasing to 21 yards westward; the second and third faults, which run more or less parallel, one on each side of Watling Street, together produce the Rising Sun Trough, in which all the coals are thrown down 20 to 37 yards, in a narrow strip 150 to 200 yards wide in the Deep Coal. Between the Hammerwich Fault and the Rising Sun Trough a pit called the Corner Pit or Coppice No. 8 Shaft, 60 yards south-west of the Old Wilkin Inn, reached the Yard at 154 ft., the Bass at 206, the Cinder at 238, the Shallow at 282, and the Deep at 334 ft., the dip being N. 20° W. at 3 in. per yard. In Nos. 6 and 7 Shafts, 300 yards to the west-north-west, the Yard was 294 ft. deep and the other coals correspondingly deeper, the Deep being reached at 460 ft.

On the south side of Watling Street, opposite Conduit Farm, the shafts of the old Conduit Colliery worked the coals in the direction of Norton Green. The No. 1 Shaft (the southern of the two shafts 300 yards west of the farm) appears to be the one of which the section was published by Jukes.[1] After passing through 71 ft. 6 in. of Glacial drift, the shaft proved the chief coals with the following thicknesses:—

Old Conduit No. 1 Shaft.

		Thickness.		Depth from surface.	
		Ft.	In.	Ft.	In.
Sulphur Coal		2	1	127	0
Yard Coal		2	10	177	6
Bass Coal		6	0	225	10
Cinder Coal		5	4	251	9
Shallow Coal		6	0	281	5
Roof coal, 1 ft. 1 in. Fireclay 3 ft. 7 in. Deep coal, 5 ft. 0 in.	Deep Coal	9	8	339	11

The workings encountered a north-east and south-west fault—the Conduit Fault—which ranges under Conduit Farm, where it has a south-eastward downthrow of 9 yards. The dip of the measures north-west of this fault is N. 25° W. at 1 in 15.

In the Rising Sun Trough, which takes its title from the roadside inn of that name, the coals were reached by the two shafts of the Cathedral Pit, which also appears to have been the pumping-pit to which the water of the pits north and south of the trough was led by several long underground adits. In the north-western shaft, of which the section was published by Jukes,[2] the coals lay at the following depths:—

Cathedral Pit, Brownhills.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Glacial drift		36	0	36	0
Coal, valueless (? the Bentley Hay Coal) ...		3	10	84	10
Coal (? the Binds Coal of Bentley)		1	1	120	0
Coal, impure (? Little Gubbin Coal of Bentley)			6	148	3
Heathen Coal		2	6	189	0
Sulphur Coal		1	8	251	8
Yard Coal		2	9	297	0
Bass Coal		6	0	346	0
Cinder Coal		4	0	384	0
Shallow Coal		6	0	416	0
Rough coal, 10 in. Dark shale, 3 ft. 2 in. Deep coal, 5 ft. 0 in.	Deep Coal	9	0	467	0

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[1] Vert. Sect., Sheet 26, No. 42. *See* also Memoir, ed. 2, p. 74.

[2] Vert. Sect., Sheet 26, No. 41. *See* also Memoir, ed. 2, p. 58, 73, 170.

South of the Rising Sun Trough the coals were got under Brownhills Common by other shafts belonging to the old Coppice Colliery. In No. 3, which is 100 yards south-east of the Rising Sun, the depths were: to the Yard, 202 ft.; to the Bass, 288 ft.; to the Shallow, 362 ft.; to the Deep, 424 ft. At 300 yards farther to the south-east, No. 1 Pit reached the Yard at 115 ft., and the Bass at 152 ft.; while in No. 2 Pit, 140 yards farther to the south-south-east, the Yard was 86 ft., and the Bass 123 ft. deep. These figures show a dip to the north-west of 3° to 6°. Between Brownhills Station (M.R.) and St. Thomas's Church the Watling Street Colliery, one of the most recent at work in this exhausted district, and within 300 yards of the Boundary Fault, proved the following section in one of its two shafts:—

Watling Street Colliery, Brownhills.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Glacial drift, and Coal Measures	...	42	0	42	0
Yard Coal	...	3	0	45	0
Measures	...	36	0	81	0
Coal, 1 ft. 6 in. Parting, 6 in. Coal, 3 ft. 0 in.	Bass Coal ...	5	0	86	0
Measures	...	36	0	122	0
Coal, 10 in. Parting, 4 in. Coal, 2 ft. 4 in.	Cinder Coal ...	3	6	125	6
Measures	...	36	6	162	0

This section probably refers to No. 1 Shaft (100 yards east of the railway-station), in which the dip is stated to be W. 25° N. at 1 in 5. If this dip continues eastward, the Yard, Bass, and Cinder coals would crop out between the shaft and the Eastern Boundary Fault. The same might be expected of the Shallow and Deep; but it appears that these coals must roll over gently towards the east, for they are shown on old plans[1] and sections, dated 1841 and 1855, as worked out to the actual fault-line near the Hussey Arms.

At Birch Coppice, south of Brownhills Common, the drift thins away for a space, and the Coal Measures occupy the surface. The wood is riddled with old shallow pits, about which no reliable information could be obtained except in respect to two of them. One of these, 150 yards N.W. of the Swan Inn, was 27 ft. deep to the Shallow Coal; the other, 90 yards farther to the north-west, reached the same coal at 48 ft., the seam dipping slightly west of north at 1 in 12. At this pit the Cinder would be about 8 ft. deep, and it may possibly be this coal that crops out in an old clay-pit behind Coppice Row, on the western side of the wood. A coal said to have been seen under the foundations of the Swan Inn, and variously referred to the Yard and the Deep, is probably the latter.

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[1] These plans (in the custody, in Oct. 1911, of Mr. Chas. Fisher, of the Coppice Colliery, to whom we are indebted for the opportunity of examining them) are (1), 'Brownhills and Norton Collieries,' signed 'Joseph Naden, Surveyor, 1841.' (2), 'Plan of Norton Manor, in the County of Stafford, to Accompany Report upon the Mines. Henry Beckett, John Southan, Joseph Cooksey.' This is dated 1855 and 1857. The plan was accompanied by a sheet of two longitudinal sections. Beckett's plan was apparently the one alluded to by Jukes (*Mem.*, ed. 2, 1859, p. 102).

Under the south-eastern side of Wyrley Common the coals were worked at three pits placed in a north-east and south-west line, and known as the Red, White, and Blue Pits. The depths in the south-western or Red Pit, and in the White (middle) Pit are approximately as follows:—

	Red Pit.		White Pit.	
	Ft.	In.	Ft.	In.
Depth to Sulphur Coal	–	–	168	4
,, Yard Coal	204	0	212	6
,, Bass Coal	238	0	268	3 ?
,, Cinder Coal	–	–	291	2
,, Shallow Coal	307	0	315	6
,, Deep Coal	362	0	369	0

A southerly downthrow of 10 yards ranges westward near the Red Pit.

Between Wyrley Common and Little Wyrley is situated Messrs. William Harrison's Grove Pit, sunk about 1857. The following is an abstract of the section[1] of the downcast, No. 2, or northern shaft:—

The Grove Pit, Brownhills.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Glacial drift and measures	161	6	161	6
Sulphur Coal	2	6	164	0
Yard Coal	3	0	207	0
Bass Coal	4	6	247	0
Cinder Coal	4	6	281	0
Shallow Coal	5	3	301	0
Deep Coal	4	6	358	6

The pit-top is about 490 ft. above O.D. The measures dip north-westward at about 2 in. per yard. The Sulphur Coal is not worked; the Yard, Shallow, and Deep are house-coals, the Bass and Cinder are steam-coals. The Bass consists of about 4 ft. 6 in. of coal and a shale parting 6 to 12 in. thick. The Cinder consists of a similar thickness of coal parted by shale 1 ft. to 1 ft. 6 in. thick. The Deep Coal has a parting of shale 5 ft. thick.

The south-eastward downthrow of 9 yards proved under Conduit Farm (p. 86) ranges past the Grove Pit. Parallel with it, and 150 yards to the north-west, a belt of small faults and a 20-yard downthrow to the south-east pass near the downcast shaft.

The ground just described about Wyrley Common is separated from that to the south by a fault with an east-south-east range and a southerly downthrow of 18 yards. From near Wyrley Grove, where its throw is 19 yards, it runs past the present Slough Colliery and then, curving northward at the Jolly Collier, becomes obscure, but probably runs along or close to Wolverhampton Lane and into the Clayhanger Fault near Brownhills (L. & N.W.) Station.

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[1] Communicated by Messrs. J. C. Forrest and W. A. Dunham.

The present Slough Colliery[1] utilizes two old shafts, of which the upcast was formerly known as the Wood Pit. The coals in this, the No. 1 or southern shaft, are believed to lie at the following depths:—the Yard, 135 ft.; the Bass, 169 ft.; the Cinder, (?); the Shallow, 234 ft., the Deep, 284 ft. The fault described above, which cuts the Shallow and Deep coals between the two shafts, is believed to have here a throw of 14 yards. North of the fault the Bass Coal was found to rise not in the east-south-east or normal direction, but towards E. 25° N., in which direction it was found near Slough Cottage to be replaced by or faulted against clunch. Average sections of the Bass, Cinder (so-called New Mine), and Deep coals give the following details:—

Slough Colliery.

Bass—	Cinder—	Deep—
Coal 2 ft. 0 in.	Coal 2 ft. 2 in.	Roof coal 1 ft. 6 in.
Dirt 8 in.	Dirt 8 in. to 1 ft.	Fireclay 3 ft. 0 in.
Coal 1 ft. 0 in.	Coal 8 in.	Coal 4 ft. 0 in.

The roof coal of the Deep, being of inferior quality, is left to support the roof. The Bass and Cinder coals are sold as steam-coals, the Deep as a house-coal.

South of the Slough Fault (the 18-yard downthrow south described above), a 4-yard upthrow south was encountered 50 yards beyond the southern shaft, and 150 yards from the same shaft a southward downthrow of 7 yards. The coals are thus thrown down about 21 yards below their level north of the fault, and the crops would be shifted eastward. They are, however, soon raised again by an upthrow of about 17 yards, proved in the Pelsall Colliery's workings and also, in the form of a belt of smaller faults, in the workings of the old Moat Colliery (130 yards S.W. of the canal bridge called the High Bridge). In this High Bridge Trough[2] the Yard, Bass, Shallow, and Deep coals were worked at the Moat Colliery, and also at the High Bridge Colliery by the canal side 270 yards S.W. of the High Bridge, at which the Sulphur Coal lay at a depth of 69 ft. and the Deep Coal at 288 ft. An old 'crowning-in' or sink in the middle of a field, 250 yards south-south-west of the old pits, is said to have been caused by the Deep Coal workings.

Farther east, beyond the L. & N.W. Railway, there are old pits in a wood, 3 furlongs south of the Jolly Collier, where some extensive subsidences, filled with water, show that much coal has been extracted. Other old pits half a mile S.W. of High Bridge, between the railway and the disused Gilpin's Arm of the canal, about none of which has any information been obtained, would doubtless have thrown light on the position of the crops. According to Jukes[3] the Deep Coal at 'Ryder's Hayes Colliery,' of which the site may be seen 150 yards N.E. of Ryder's Hayes Farm, was 120 ft. deep, the Shallow being the only coal above it. He also adduces evidence of a downthrow north of 20 yards just south of that colliery, and of another and parallel fault of like downthrow just south of the Moat (at the cross-roads half a mile S.W. of High Bridge). In the High Bridge Trough it is possible that only the Sulphur, Yard, and Bass coals cropped out, and that the lower seams ended against the Clayhanger Fault.

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[1] Information from Mr. Walter Beaizley.

[2] Jukes, *op. cit.*, ed. 2, pp. 73, 170; *Vert. Sect.*, Sheet 26, No. 46.

[3] *Op. cit.*, ed. 2, pp. 169, 170; *Horiz. Sect.*, Sheet 45, No 1.

Pelsall District.—At Pelsall the Glacial deposits become thin enough to be cut through by the streams, and the Coal Measures are exposed in the valley between Heath End and Goscote. Jukes[1] records that the crop of the Deep Coal has been seen in Rail's Wood, north of Pelsall Station. The coal not far from the crop has more recently been worked by the Heath End Colliery under Pelsall Common, from a line joining the church and the station south-westward past the now disused Heath End Brickworks and into the valley, where the coal was brought out at a day-hole. The seam was found to dip slightly north of west at 1 in 4, and has been worked to within 170 yards of the station. At the brick-works the coal appears to have lain not far below the surface, and at another old brick-works, a quarter of a mile farther to the south-east and 250 yards north-east of Goscote Lodge, what is presumably the same coal was visible in 1911. This latter exposure appears to be the one alluded to by Jukes as visible in 1858. In this neighbourhood the Deep and Shallow coals come together, according to Jukes, by the thinning-out of the intermediate measures, and the resultant coal is known in the district lying to the south-west as the Bottom Coal.

Farther to the north-west, the Deep and some of the overlying coals were worked at the Pelsall Hall Colliery by a pair of shafts situated 100 yards south-south-west, and by another pair 400 yards south-east, of the Hall. In the latter, the western shaft (No. 3) showed the following section:—

No. 3 Pit, Pelsall Hall Colliery.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Soil and red clay [Glacial drift]	8	4	8	4
Binds	28	8	—	
Yard Coal	3	0	40	0
Fireclay, rock, binds	28	0	—	
Coal 1 ft. 6 in. Parting 1 ft. 0 in. Coal 2 ft. 6 in. } Bass Coal	5	0	73	0
Clunch, binds, fireclay, rock, bat	60	0	—	
Cinder Coal	4	0	137	0
White rock	19	0	—	
Shallow Coal	6	0	162	0
Bat		3	—	
Deep Coal	6	0	168	3

It will be noted that here the Shallow and Deep coals are separated by only 3 in. of bat. In the north-western (No. 2) shaft near Pelsall Hall the same coals are separated by 6 ft. of dark fireclay; while still farther to the north-west, the intermediate beds consist of 27 ft. of dark fireclay and white rock. The general dip here is north-west at 1 in 24. Between Pelsall

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[1] *Op. cit.*, ed. 2, p. 72.

Hall and Goscote the Hope Colliery worked the Bass and Main coals (the latter is presumably the Bottom or Deep Coal); the plan shows the occurrence of 'brazil,' *i.e.*, coal spoiled by trap-rock, in the Main seam.

A mile north of Pelsall Hall the coals were worked by several shafts at the Pelsall Colliery. Here the Shallow and Deep coals are separated by 38 ft. 8 in. of measures, including a coal 1 ft. 8 in. thick, and the first coal reached in the shafts was a seam 2 ft. 2 in. thick lying 52 ft. above the Sulphur Coal. At a colliery hereabouts, known as Haddock's Moor Colliery,[1] a shaft, sunk into the beds below the Deep Coal, proved the following measures:—

	Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Deep Coal	—		—	
Fireclay	9	0	9	0
Gubbin ironstone	2	6	11	6
Coal		6	12	0
White rock, fireclay with ironstone; rock and peldon, clod	36	6	48	6
Mealy Grey Coal	1	4	49	10
Binds, rock, clod, fireclay	34	6	84	4
Coal		6	84	10
Fireclay, rock, clod, dark soft binds ...	76	6	161	4
Dark soft binds, bored into for	9	0	170	4

The Goscote Hall Colliery was situated within a bend of the canal, a quarter of a mile south-east of Goscote Hall. Though the several shafts are all stated on the plan to be 86 yards deep, this is unlikely, and does not agree with a MS. section[2] of 'No. 2 Shaft,' in which the top of the Bottom Coal is said to be 177 ft. from the surface. The plan shows the Bottom Coal to be 12 ft. thick and to be much cut up by 'rock,' presumably igneous; in a north-westward direction the coal ends against 'green rock.' At Coal Pool, a little farther south, a small area of Coal Measures is exposed in the floor of a valley, where the Bottom Coal crops out and has been at some time worked by shallow holes,[3] and later at the Coal Pool Colliery. The shafts, which are situated just east of the canal, 150 yards north of Coal Pool Bridge, are stated on the plan to be 25 yards deep. On the west and south the workings seem to have got into Glacial sand, and on the east into old gobs and bad coal. The seam is said to dip about north-west at 1 in 30, and to range south-westward toward the Birchills.

Walsall.—The measures below the Bottom Coal containing the Gubbin, Blue Flats, Silver Threads, and Diamonds ironstones, and the Mealy Grey Coal, are buried under Glacial drift. The coal was probably not worth working, though the last three ironstones were got about 1850 by some shafts at Ryecroft,[1] of which the sites and tips are covered by the Walsall Cemetery. The Blue Flats ironstone is said to lie 90 ft. below the Bottom Coal. Jukes gives the following details of the ironstones:—

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[1] According to a MS. section by Jukes the colliery was situated "south-east of Woodhouse, over the *t* of '*Essington Canal,*' Pelsall." This would place it on Wood Common, about 150 yards N. W. of Friar Bridge on the Cannock Extension of the canal (see six-inch map, Staff. 57 S.E.). See Jukes, *op. cit.*, ed. 2, p. 76; *Vert. Sect.*, Sheet 26, No. 43; *Horiz. Sect.*, Sheet 45, No. 1.

[2] Recorded by Jukes in a MS. section-book preserved in the Geological Survey Office. On the Goscote district, see also Jukes, 'Memoir,' ed. 2, pp. 72, 130.

[3] Jukes, *op. cit.*, ed. 2, p. 72.

Ironstones at Ryecroft.

		Ft.	In.
Blue Flats	Ironstone cake		3
	Blue clod	1	0
	Ironstone		3
	Blue and white clod	3	7
	Ironstone balls, called 'grandads'		8
	White clod	10	0
Silver Threads	Ironstone		3
	White clod	2	8
	Ironstone		4
	White clod	3	0
	Ironstone		3
	White clod	7	6
	Balls of ironstone (in places)		8
	White clod	7	0
Diamonds	Ironstone		3
	Black clod	2	0
	Ironstone		4

According to Jukes's MS. one of the Ryecroft ironstone-pits was sunk through the base of the Coal Measures down to the Upper or Thin Limestone of the Wenlock, a 6-ft. band of 'rough rock' immediately below the Diamonds ironstone forming the basement-bed of the Carboniferous, at a depth of 150 ft. from the surface.

The general north-westerly dip of the measures at Coal Pool, and the fact that at Ryecroft the shafts commenced below the outcrop of the Bottom Coal, prepare us to find the Blue Flats, Silver Threads, and Diamonds ironstones cropping out not far to the south-east of Ryecroft. A line of old diggings in a field immediately west of the junction of Cart Bridge Lane and Lichfield Road probably marks the crop of an ironstone, or of the Mealy Grey Coal. Extensive but shallow diggings are visible in the fields alongside and north of the Mellish Road between Leigh Road and Fern Leigh, and again 150 yards north of Rushall Hall. Still farther north similar excavations may be seen in a field west of the disused 'church' at Daw End. Below the ironstones a variable thickness of measures is met with before the Silurian rocks are reached. At Ryecroft these basement-beds, as we have seen, appear to be only 6 ft. thick; but at Bentley they vary from 19 ft. to over 24 ft. or more.

The actual base of the Coal Measures leaves the Clayhanger or Daw End Fault at the northern end of the old limestone-quarry at the Radleys, Daw End, where it rests on the Lower Ludlow and Upper or Thin Limestone of the Wenlock (p. 20). At the Radleys it turns south-eastward, and extends across the outcrop of the Nodular Beds. In the south-east corner of an old shallow clay-pit 300 yards north of the Royal Oak Inn at Daw End, a section, visible in 1911, showed ferruginous yellow and buff shales of the Coal Measures resting on the Nodular Beds, the latter forming a small inlier at the bottom of this part of the excavation. A few yards farther west other exposures show that the materials excavated for the bricks consisted of green shales, with some white quartzose sandstone and grit, the latter being composed of small pebbles of ironstone, quartz, and mudstone, bound together by a ferruginous cement. These Coal Measure basement-beds dip W.S.W. at 25°.

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[1] Jukes, *op. cit.*, ed. 2, pp. 79, 84. *Vert. Sect.*, Sheet 16, No. 7.

Farther to the south-east several sinks in the fields, where the roof of the underground quarry in the Lower or Thick Limestone has given way, show that the Nodular Beds are overlain by 10 or 12 ft. of yellow ferruginous Coal Measure sandstones; and a still better section is afforded by the mouth of an old descending drift, 350 yards east of the Royal Oak, by which access was formerly gained to the limestone-workings (p. 18). Here about 12 ft. of brown, yellow, and grey sandstones and sandy shales, irregularly stratified, with coaly markings on some of the bedding-planes, overlie the Nodular Beds. The dip is undulating, and in one place appears to be south or south-west at 8°. The junction with the Silurian seems slightly uneven. Below the junction the uppermost of the Nodular Beds are in one place converted to a depth of 6 ft. into a brown ferruginous soft rottenstone in which a few small scaly nodules of ironstone are present. Evidently the iron-charged Coal Measure waters deposited some of their iron in the Silurian limestone and shales with which they were in contact, in the same manner as we have seen took place in the railway-cutting close by (p. 18).

East of this section the sandstones overstep the Lower or Thick Limestone and rest on the Wenlock Shales. The junction then turns westward along the northern edge of the cutting on the Midland Railway into the fault (p. 17), from which it emerges again a short distance west of the canal aqueduct. It then runs south-westward along the edge of the Park Pits, where the lowest Coal Measures, in the form of yellow and black shales with ironstone-nodules, can be seen in contact with or close above the lowest of the Nodular Beds. West of Fern Leigh the Coal Measure basement-beds are chiefly yellow sandstones, the debris of which can be seen about the old quarries in the Lower Limestone (p. 19) till we reach Moss Close, where a fault with northward downthrow cuts them off and throws the base westward under the drift and alluvium towards Ryecroft.

South of the centre of Walsall the Moat Fault, a southward downthrow of 120 ft. in the Coal Measures west of the town, throws the measures eastward again. The effect on the base of the Coal Measures was not fully realized by Jukes, who consequently placed the base about 3 furlongs too far to the west. It is now known that beneath the Glacial drift the Coal Measures extend under that part of the town which lies south of Birmingham Street, for a well at the Highgate Brewery, sunk in 1898, proved 32 ft. of Coal Measures under the Glacial drift and over the Silurian (p. 19). The following is the section:—

Well at Highgate Brewery, Walsall.

		Thickness. Ft.	Depth. Ft.
	Made ground (filling of old gravel-pit)	12	12
Glacial ...	Yellow clay, 1 ft. to 3 ft., say ...	1½	13½
	Gravel	2	15½
Coal Measures	Dark ground	2	17½
	Ironstone measures (Blue Flats, Silver Threads, and Diamonds), about	16½	34
	Binds	½	34½
	Blue binds with bands of stone...	9	43½
	Blue and brown rock, intermixed	4	47½
Silurian ...	Limestone binds with bands of stone	69	116½

A heap of ironstone-nodules in the brewery yard yielded *Lingula mytiloides* J. Sow. and traces of 'fern'-leaves; the bed itself crops out on the flat ground south of Belvidere Road, 150 yards south-east of the brewery, where there are signs of old diggings. The base of the Coal Measures appears to leave the Moat Fault at the Wheatsheaf at the junction of Birmingham Street and the Birmingham Road, follows the latter for a space, crosses Jesson's Lane and Gorway Road, and then leaves the map in the direction of Maw Green.

(2) *The Concealed Area, east of the Clayhanger Fault.*

At the time of Jukes's survey (1847-58) the productive measures underlying the 'red clays of the upper coal measures' on the eastern side of the coalfield, between Brownhills and Aldridge, were only beginning to receive the attention of the colliery proprietors.

The first attempt to reach the coals under this tract appears to be that made about 1849 "a little north of the Red House" at Aldridge, where a trial-pit,[1] known later as the Victoria Colliery (p. 98), proved a number of coals in measures that dipped N.N.E. at 30°. The shaft commenced below all the 'red clays', which occupy the surface farther north and had long been worked for bricks. The results of this trial led the Rev. Baily Williams to sink still farther north, at Stubbock's or Stubber's Green, through the red clays themselves, and accordingly the Coppy Hall shafts were put down[2] about 1857. These shafts proved a number of coals, believed to represent the Wyrley seams, and were subsequently deepened to the Shallow and Deep seams.

Since Jukes's time the coals have been reached at the following additional collieries:—Leigh's Wood, Aldridge, and Walsall Wood, all of which penetrate a considerable thickness of Etruria Marls.

Walsall Wood Colliery.—The two shafts of the Walsall Wood Colliery, sunk about 1874, are situated half a mile north of Walsall Wood Station (M.R.). In the northern, downcast, or No. 1 shaft, which passed through faulted ground at several depths, the Deep Coal was reached at 1,677 ft. The southern, upcast, or No. 2 shaft, after reaching the Yard Coal at 1,624 ft. 6 in., likewise entered faulty ground, and at 1,743 ft. entered 'green rock' (igneous) and continued therein to the bottom at 1,752 ft. Neither section is satisfactory, as the true thicknesses between the various coals are not clearly ascertained. It will be shown later that the red rocks at the surface are indistinguishable from the Keele Beds (the 'Permian' of the old map of Jukes). If this identification is correct, the shafts should have passed through the grey and yellow Newcastle or Halesowen Sandstones between the Keele Beds at the surface and the Etruria Marls below. But no such beds are recorded in the shaft-sections; the colours mentioned are predominantly red. It follows, therefore, that either the Halesowen Sandstones have assumed a red colour, or the surface-beds, in spite of their resemblance to the Keele Beds, must be Etruria Marls. The bottom of the red beds in No. 2 shaft at Walsall Wood appears to be at 925 ft. 11 in., a figure somewhat in excess of the known thickness of Etruria Marls on the western side of the coalfield, and this fact supports the view that the surface-beds at Walsall Wood are Keele Beds.

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[1] Jukes, *op. cit.*, ed. 1, p. 231; ed. 2, pp. 99, 100. Also *Vert. Sect.*, Sheet 16, No. 4.

[2] Jukes, *op. cit.*, ed. 2, pp. 98-102.

The following coals are or have been worked at the colliery:—

	Thickness.	
	Ft.	In.
Seven-Foot (house and manufacturing coal) ...	7	6
Four-Foot " " " ...	4	3
Six-Foot " " " ...	6	3
Yard " " " ...	3	2
Bass (not now raised)	4	2
Shallow (house coal)	5	0
Deep (house coal)	4	6

The section of the Bass Coal shows binds 9 in., top coal 1 ft. 10 in., bass 1 ft., bottom coal 1 ft. 11 in., on hard fireclay. The Six-Foot contains 5 to 15 in. of dirt in addition to the 6 ft. 3 in. of coal. The Deep Coal has, in addition to the 4 ft. 6 in. of house coal, a roof of steam coal 1 ft. thick. Coals called the Five-Foot and Eight-Foot are not worked. Considerable local thickening and thinning of some of the individual seams has been met with: under Catshill the roof and bottom coals of the Deep Coal are separated by 25 ft. of intermediate measures which, under Vigo, 1½ miles to the south, are absent. West of Vigo the Shallow Coal is scarcely separated from the Deep.

The only ironstone raised comes from chance bands, one above the Shallow Coal, the other between the Shallow and the Deep. A bed of blackband ironstone, 22 ft. below the Four-Foot Coal, is said to contain marine fossils. A heap of blackband ironstone from the roof of the Four-Foot, and lying on the surface at the colliery, though apparently of no commercial value, yielded the following fossils[1]:—

Calamites sp.
Lepidodendron sp.
Naiadites sp.
Diplodus ?
Rhizodopsis sauroides (*Will.*)
Strepsodus ? (tooth)
Fish teeth and scales

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[1] T.C.C. 2066-78, Pl. 3462-3473.

The area worked by the colliery is bounded on the west by the Clayhanger Fault, and on the east by the Eastern Boundary or Vigo Fault. Between these limits the dip of the measures varies considerably. Midway between Catshill and the shafts it has a general north-westward direction at 3·9 inches in the yard; farther west the dip steepens, till a synclinal axis is reached at Clayhanger, west of which the measures rise toward the Clayhanger Fault (*see* Section on Sheet 154). The syncline thus indicated probably ranges southward, for westward dips of 1 in 12 have been met with in the Shallow and Deep coals within 400 yards north-west of the Old Horse and Jockey, between Walsall Wood and Shelfield. In the northern part of the workings under Ogley Hay church the Shallow Coal dips N. 25° W. at 24 in. in the yard.

The area is crossed by several faults. Some of these have a north-and-south range, parallel to the bounding faults, as for instance a 90-ft. fault proved in the Six-Foot under Brownhills Gas Works, and ranging thence southward towards the shafts. Others run nearly east-and-west; such as a series of three northward downthrows with a total displacement of 120 ft., proved in the Deep Coal 300 yards south-east of the southern shaft. It was possibly the northernmost of these that afforded a passage for the igneous rock met with at the bottom of the same shaft. Parallel to these faults, and some 200 yards to the north, a southward downthrow of 20 yards ranges toward the northern shaft, and so forms a trough, in which the Deep Coal was found to be burned by the igneous rock.

The recent explorations conducted at this colliery in an attempt to reach the coals under the red rocks east of the Boundary Fault will be described later (p. 167).

Aldridge Colliery.—A mile south of Walsall Wood Colliery the two shafts of the Aldridge Colliery, sunk about the year 1874, and commencing in the Etruria Marls, reach the Deep Coal at 1,340 ft. The section of one of these shafts is given in the Appendix (p. 227); it is not known to which of the shafts it refers, but as the shafts themselves are only 15 yards apart, and the ground does not appear to be faulted, this is not of much consequence. That the surface-beds are referable to the Etruria Marls admits of no doubt, as the red marls and espley rocks of the latter are finely displayed in adjacent brick-pits. The shaft-section shows that red marls predominate down to a depth of 499 ft., which may be taken as the base of the Etruria Marls. The following are the chief coals, with their thicknesses and depths:—

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Seven-Foot (coal 18 in., bat 3 in., coal 18 in., bat 9 in., coal 4½ ft.)	8	6	776	1
Four-Foot...	4	0	794	0
Five-Foot (coal 2ft. 6 in., parting 6 in., coal 3 ft.)	6	0	834	3
Brooch	2	6	872	3
Yard	3	6	1,222	9
Shallow and Deep (coal 6 ft. 8 in., bat 3 in., coal 1 ft. 7 in., bat 4 in., coal 4 ft. 11 in.) ...	13	9	1,340	11
Bottom of shaft	—		1,397	7

The Seven-Foot and the Four-Foot are worked together, as also are the Shallow and Deep. The Brooch, a coal of high quality, is being worked, but the Five-Foot and the Yard are not now raised. Some of the gubbin ironstone just above the Four-Foot Coal is occasionally brought down in working the coal, and when a few tons of it have accumulated it is sold to the iron-makers.

The Blue Flats ground shows the following details:—blue binds 2 ft., blue ironstone 2 ft., stone 3 in., clod and stone 2 ft., blue binds 6 ft. 6 in.

At the surface the dips in the Etruria Marls are more or less northward, at angles rising from 0° to 5°. In the Seven-Foot Coal an eastward downthrow of 60 ft., parallel to the Boundary Fault, ranges southward from Vigo.

At Stubber's Green the two shafts of the Coppy Hall Colliery[1] passed through at least 218 ft. of Etruria Marls, but the exact thickness is uncertain, as grey (or green) and red shales interstratified with dark-grey and black measures are recorded still lower. The following is an abstract of the section:—

Coppy Hall Colliery, Aldridge.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Red marl	210	6	210	6
Seven-Foot Coal	7	6	645	3
Gubbin Ironstone	5	0	—	
Four-Foot Coal	4	0	680	9
Five-Foot Coal	5	7	717	4
Three-Foot Coal	2	10	761	10
Sulphur Coal	1	7	1,077	9
Yard Coal	3	3	1,123	1
Fireclay Coal	4	6	1,182	1
Roof Coal	1	8	1,183	9
Measures	57	0	1,240	9
Shallow Coal } in contact	7	1	—	
Deep Coal }	4	7	1,252	5

On the Home Office Plan (3992) the bottom part of the section is given as follows:—

	Ft.	In	
Coal	1	8	
Binds	18	0	
Shallow Coal	7	10	
Bat		8	
Deep Coal	3	9	at 1,252 ft. 5 in.
Fireclay	—		—

Immediately north of the pits the Deep Coal dips northward at 1 in 18. About 30 yards south of the south-eastern (No. 1 or downcast) pit a southerly downthrow of 21 ft. in the Deep Coal ranges from Stubber's Green in a direction of E. 13° N. West, south-west and south of Stubber's Green the coals have been found to rise at 1 in 5 toward the Clayhanger or Daw End Fault. This strong rise prepares us for the emergence of the base of the Etruria Marls, and the consequent outcrop of the productive measures, along the north-eastern side of the fault, from the Lichfield Road, past Linley Farm, to the Vigo Fault at Pool

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[1] Jukes, *op. cit.*, ed. 2, p. 99. *Vert. Sect.* Sheet 26, No. 44. Information from Mr. S. L. Thacker.

Green, where the shafts of the Victoria Colliery (the Aldridge Trial Pits of Jukes) show the Etruria Marls to be absent (pp. 94, 116).

The Leigh's Wood Colliery is now worked by the Aldridge Colliery Company. The pits were sunk in 1874; after passing through 361 ft. of Etruria Marls, below which the grey measures and upper coals were traversed, the shafts reached the Seven-Foot Coal at 652 ft. and the Deep Coal at 1,231 ft.

The most southerly workings in this tract are those of the Victoria Colliery (the Aldridge Trial Pits[1] of Jukes). Three shafts appear to have been sunk, of which two, sunk about 1849, can still be identified; the site of No. 3, sunk in 1872, is said to be covered by sidings of the Midland Railway. In No. 1 or No. 2 the Glacial drift appears to be 43 ft. thick. Then follow grey rock, brown and red clod, dark binds and black clod, mine earth and clod, with the first coal, 2 ft. 9 in. thick, at 108 ft. from the surface. These beds are certainly lower than the Etruria Marls, the base of which may be estimated to crop out about 50 yards north of No. 1 (the north-eastern) shaft. The Seven-Foot was reached at 275 ft., the Four-Foot at 318 ft., the Five-Foot at 388 ft., and the Brooch at 413 ft., below which, binds with thin grey rocks extended to the bottom of the shaft at a depth of 500 ft. The dip of the measures was found to be N.N.E. at 18 inches per yard (26°), diminishing northward to 22½°.

The colliery worked small areas of the Seven-Foot Coal, the Gubbin Ironstone, the Four-Foot Coal, the Brooch or Yard Coal, and a band of ironstone called the White Ironstone. None of the workings extended eastward of what is now the line of the Walsall Wood branch of the Midland Railway, and there is no evidence that the Vigo Fault was touched. It is probable that the measures sunk through in the shafts are cut off along the Walsall railway on the south by a southerly downthrow, which brings in a triangular area of Etruria Marls at Pool Green (p. 116).

One of the shafts has since been sunk to the Deep Coal at 853 ft. from the surface.

WESTERN SIDE OF THE COALFIELD.

By W. GIBSON.

North of the Bentley Fault the geographical arrangement will be adhered to; but to localise the descriptions more closely the area will be considered as portioned out into blocks of which the boundaries are determined by the principal faults. Of these the north and south Mitre Fault extending from near Short Heath to a little south of Cannock town forms the boundary between the older workings on the east and the newer ones on the west. North of Cannock a fault on the same line and with a similar large downthrow west separates the workings on the east from those of the recently developed Littleton Colliery on the west.

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[1] Jukes, *op. cit.*, ed. 1, 1853, pp. 231-2; ed. 2, 1859, pp. 99-102. *Vert. Sect.*, Sheet 16, No. 4.

East of the Mitre Fault.

This area may be sub-divided into (*a*) a block lying north of the east and west Littleworth Fault; and (*b*) into a block situated to the south of this fault. The northern district contains the more important modern pits, and is commonly known as the Cannock Chase coalfield: in the southern area there are several working collieries, but a great part of the coal has been extracted by numerous and now abandoned pits.

a. North of the Littleworth Fault, near Hednesford, the Coal Measures are chiefly concealed under the Trias except along the main valley where also the outcrops are for the most part covered by thick masses of glacial sands and gravels.

The old workings of the Fair Oak Colliery N.E. of Brindley Brook have been previously mentioned (p. 75). One mile to the west a trial-boring for coal, situated on the north side of the road going N.E. from Broadhurst Green reached Coal Measures at a depth of 327 ft. at a spot close to the figures 645 on the One-inch Map. To the south of the boring the Deep Coal is being worked from the West Cannock Colliery beneath the Bunter cover up to a fault of 54 ft. down west under the north-west corner of Brindley Wood, the seam striking nearly north and south and dipping west. At the boring the Coal Measures are 318 ft. above O.D., but a rise of the carboniferous floor brings them to an elevation of 580 ft. in an old clay pit 200 yards south of St. Saviour's Church, Hednesford, from whence it continues to rise to 600 ft. at No. 1 Pit, West Cannock Colliery. Coal Measures, under a varying cover of glacial drift, floor the main valley and the Littleworth tributary, but the Bunter Conglomerate is at a slightly higher elevation on the west side of the main valley. The workings of the collieries mentioned show that a local syncline, which introduces the Etruria Marls at East Cannock and Littleworth, runs roughly parallel with the main valley, the coals rising to the west on the west side, and to the south-east and north-east on the east side.

The sections of West Cannock No. 1 Pit, and those of Pool Pits and of East Cannock present a general agreement in the order of the coals between the Deep Coal and Yard Coal. Above the Yard Coal, the Old Park Coal (Main Hard of West Cannock) maintains a constant position, and above this seam the Four Feet Coal and Five Feet Coal occur at East Cannock and West Cannock, and seams in the same position, but unnamed, are present in the Pool Pits. The intermediate measures consist of alterations of binds and rock binds. At West Cannock, presumably No. 1 Pit, Molyneux[1] states that a dark shale lying above the greater proportion of the workable coals yielded some of the marine shells occurring in the New Mine stone and Pennystone Ironstones of Oldbury (Jukes, *op. cit.*, p. 27 and 58), which at West Cannock would lie between the Old Park and Yard coals.

The seams most extensively worked are the Shallow, Deep, and to a less degree the Bass, Five Feet and Old Park, the coals being classed as House, Manufacturing and Steam. The Main Hard of

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[1] *Geol. Mag.*, 1873, p. 17.

West Cannock yields one band of good house coal, another free from sulphur and much used in brassworks, while the remainder is adapted for steam and forge purposes.

The structure of the area is simple as will be seen from the illustration (Fig. 3, p. 101). From the centre of the basin at East Cannock, where the Deep Coal lies 648 ft. below O.D. the seams rise to the north-east, so that this coal is 464 ft. below O.D. at the Pool Pits of the Cannock and Rugeley Colliery on the east side of the syncline. The measures rise continuously to the west up to the Huntington Fault (p. 105).

b. South of the Littleworth Fault.—A tract of coal measures, about two miles in width, has been worked continuously up to the Bentley Faults. The presence of numerous faults, and the absence of exposures of the measures, owing to a thick and almost universal covering of glacial deposits, render it impossible to draw on the map, within practical accuracy, the outcrops of the various coals.

In the northern part of the area the coal seams at No. 9 Pit Cannock Chase (No. 1 Fig. 3, p. 101) agree in position and receive the same names as around Hednesford. At Brownhills Colliery No. 3 Plant (Appendix, p. 233), the lower coals, between the Sulphur and the Deep, also retain the same names; but in the Bloxwich district the Shallow and Deep coals unite to form the Bottom Coal; while the Bass Coal of the northern section becomes the Five Feet Coal, and the Cinder Coal is known as the Fireclay Coal. The Old Park Coal of No. 9 Pit Cannock corresponds in position with the 8 ft. Coal (sometimes, as formerly, called the Bottom Coal of the Wyrley sections); but the Four Feet Coal above the Old Park Coal at No. 9 Pit is not recognised in the southern sections where the name is given to a seam below the 8 ft. Coal.

So far as is known and can be judged from the records the intermediate measures do not contain any distinctive bed. For the most part the measures are described as binds (shales), clunches (marls), fireclays with thin lenticular beds of sandstone, sandy shales forming a subordinate constituent. Igneous intrusions, chiefly inserted between the Shallow and Deep coals, are common in the Bloxwich region, but are absent north of the east and west fault crossing Landywood.

The coals which have been or are still worked are, in ascending order: Deep, Shallow, Fireclay, Bass (Five Feet) and Yard among the lower seams; in the north the Five Feet and Four Feet coals, above the Old Park, are mined; and in the south the Four Feet and Heathen coals below the Old Park Coal.

The general dip of the measures lies between two and six degrees directed N.W. or W.N.W. The rise to the S.E. would bring the lower seams (Deep to Yard) to the surface in the south around Bloxwich, but owing to a series of faults having a downthrow east these seams are present over the whole area. The main faults are orientated N.E. to S.W., of which the Leacroft Fault, with a downthrow east from 75 ft. in the south to 240 ft. in the north at the Cannock Leacroft Colliery, is the more important and persistent dislocation.

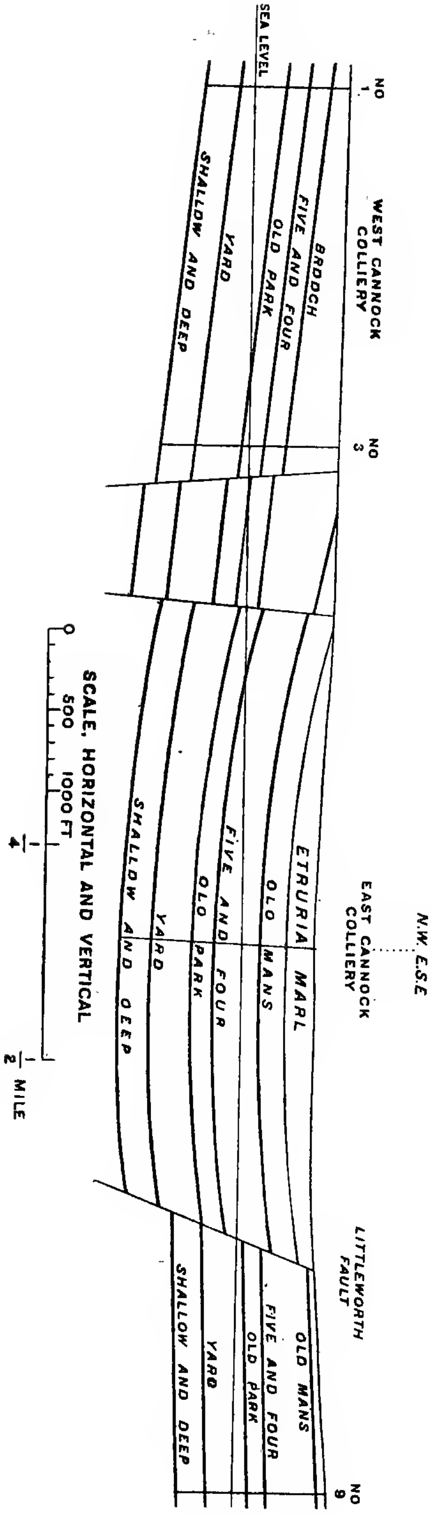

FIG. 3.—SECTION THROUGH THE HEDNESFORD SYNCLINE.

Leacroft and Great Wyrley.—This area comprises a block bounded by the Littleworth Fault on the north, the Landywood Fault on the south and the Mitre Fault on the west.

The order of the coals is given by the sections of the shafts of Cannock No. 9 Pit (p. 240), Brownhills No. 3 Plant (p. 233), and those of Great Wyrley (p. 241). Each commences above the horizon of the Eight Feet (Old Park Coal).

The glacial drifts are absent around No. 9 Pit Cannock Chase Colliery, but give rise to a prominent ledge on the south side of the Littleworth Valley and along the east side of the Ridings Brook as far south as Rumer Hill. Old workings show that the Coal Measures are at the surface below the ledge, and Jukes (*op. cit.* p. 103), gives the following details of a section of a shaft near Cannock Mill, Mill Green:—

	Ft.	In.
Red marl	6	0
White binds	12	0
Cannel Coal	3	6
Bind measures	24	0
Rock	3	0
Two-foot Coal	2	0
Binds, rock binds, clunch etc.	72	0
Coal	4	6
Measures	90	0
Stinking Coal	5	0
	222	0

On the west, Cannock side of the valley, glacial drifts entirely obscure the outcrops, and in the absence of explorations it is uncertain whether the drifts rest on coal measures as now shown on the map or on Bunter Sandstone.

On the east side, the Etruria Marls, resting on grey measures, have been excavated on Rumer Hill. In an old shaft ¼ mile to the south-east the Wyrley Bottom (Eight Feet) Coal is said to be 453 ft. below the surface.

South of Watling Street the drift-plateau is dissected by the Wyrley Brook and its tributaries, but if the Coal Measures crop out at all in the bottoms of these drainage channels they are hidden under alluvial deposits and a downwash of Drift. The somewhat conspicuous features of the higher ground are formed of Drift, and there is no indication at the surface of the complicated faulting proved in the workings of the Brownhills Colliery (p. 100).

Around Great Wyrley Colliery the Drift is thin and in places absent, but there are no open sections of any consequence or on the driftless high ground of Cheslyn Hay.

Bloxwich area.—The country south of Landywood up to the Bentley Faults has been extensively mined for coal and ironstone. Very many of the workings are now closed and of these explorations the information obtainable is very scanty. There is very little change in the order of the seams, and their names also are those in use at Great Wyrley.

The greatest depth to the Deep Coal is on the downthrow side of the Leacroft Fault, in the workings of Norton Cannock

Colliery, where the seam lies 636 ft. beneath the surface. The measures rise to the south-east, but as previously mentioned, owing to a series of faults with an aggregate downthrow east, the coal does not reach the surface as it otherwise would do to the east of Little Bloxwich. West of this town, about Wood Farm Colliery, there is a local change in dip to the S.W., accompanied by some faulting.

Igneous intrusions (green rock of the records) are frequent and become increasingly abundant as the workings approach the Bentley Faults and are probably the chief deterrent to mining operations. The workings at present lie to the west of Bloxwich in the seams between the 8 ft. Coal and the Deep Coal, the shafts being situated on the downthrow side of the Leacroft Fault.

There are few surface exposures over this drift-covered area, and for this reason and owing to the faults known to occur in the coal-workings but generally speaking with their direction and throws imperfectly proved, it has been found impracticable to draw any outcrops on the map.

In the ground east of the Leacroft Fault the rise of the measures to the S.E. brings the Deep Coal from a depth of 636 ft. below the surface in the shafts of the Norton Cannock Colliery, situated on the west side of the main Cannock road, near Hobble End, to 348 depth in the shafts 700 yards to the S.E. In the Lodge pits of the same company the coal is at a depth of 447 ft. To the east, in the Fishley Collieries No. 1 Plant, the depths to the seams are given[1] as Bass Coal 111 ft., Cinder Coal 160 ft., Shallow Coal 187 ft., Deep Coal (6 ft. 6 in. thick) 222 ft. Two faults cross the area between Norton Cannock and Fishley—one on the west with a throw of 180 ft. down S.E. and another 150 yards to the E. with a downthrow N.W. of 210 ft. At the Old Goscote Colliery, close to the south bank of the canal where it has turned east, south of Little Bloxwich, the coal is 210 ft. below the surface, but as no less than 100 ft. of igneous rock occurs between the Yard and Shallow Coal, the actual thickness of measures is so much the less. The section given on the Home Office Plan is as follows:

Goscote Colliery, Little Bloxwich.

	Ft.	In.
Sand and gravel	28	6
Blue binds	19	6
White rock	15	0
Batt	0	6
Yard Coal	2	6
White rock	24	0
Batt	5	0
Green rock (igneous intrusion)	100	0
Batt	3	0
Shallow Coal Batt parting Deep Coal } Bottom Coal	12	0

The parting between the Shallow and Deep Coals is a mere film, the two coals forming practically one seam called the Bottom Coal.

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[1] Home Office Plan.

Between Bloxwich, Leamore, and the North Bentley Fault, near North Walsall Station, numerous old shafts have reached the coals and ironstones, but reliable records of the sinkings and workings are difficult to obtain. At Woodwell Colliery, between the canal and Cannock Railway at the Hatherton Furnaces, the Deep Coal is 320 ft. from the surface, beneath which the shafts were sunk to the Diamond ironstones to a depth of 439 ft. At the Birchills Hall Colliery, on the west side of the Bloxwich Road and near the Staffordshire Iron Works, the Deep Coal lies 135 ft. from the surface. On the east side of the road near Pratts Mill Bridge, the following section was scaled from a Plan (Home Office) of the workings of the Deep and Shallow coals of the North Walsall Colliery:—

		Depths. Ft.	In.
Soil	Drift	3	6
Sand		18	6
Binds		45	6
Sand		60	6
Rock binds		75	6
Sand		88	0
Binds		90	8
Coal		102	0

Above the coal, most if not all of the material may be relegated to the Drift. On the plan the workings are shown to end off towards the S.E. in sand. That the workings encountered igneous rock is shown by the section of No. 11 Pit, Forest Colliery, near the Black Horse Inn, Leamore:—

No. 11 Pit, Forest Colliery, Birchills.

	Depth. Ft.
Yard Coal	66
Four-feet Coal	108
Fireclay Coal	139
Top of green rock	168
Bottom of green rock	252
Bottom Coal	264

The 'Green Rock' ends off north of Birchills Railway Station.

West of the Cannock Railway the glacial drifts are absent or thin but the surface is largely occupied by spoil heaps from numerous old shafts. Partially obscured sections of the coal measures can be seen in old clay pits north of the Hatherton Furnaces, on the north side of Willenhall Lane and Sneyd Lane.

Further west around Short Heath and New Invention up to the Leacroft Fault, there are numerous old pits and some working collieries of which those of Wood Farm, Allens Rough and Sneyd Pits No. 6 (formerly Essington Farm Colliery), are the more important. The following section at Sneyd No. 6 applies generally to this district. The shafts are situated close to the bend in the Wyrley and Essington canal east of Sneyd Farm.

Sneyd No. 6 Pit.

From Mr. F. N. Forrest.

		Thickness. Ft.	In.	Depth. Ft.	In.
Soil, clay, sand and gravel		9	10	9	10
Yellow clay		9	9	19	7
Measures		71	0	90	7
Eight-feet Coal		6	0	96	7
Measures		56	2	152	9
Four-feet Coal		3	0	155	9
Measures		62	10	218	7
Heathen Coal		2	5	221	0
Measures		55	9	276	9
Stinking Coal		1	8	278	5
Measures		43	10	322	3
Yard Coal		2	6	324	9
Rock and measures		49	4	374	1
Coal	Five-feet Coal	2	0	376	1
Batt		1	2	377	3
Coal		2	8	379	11
Batt		1	4	381	3
Coal		1	4	382	7
Batt		1	3	383	10
Rock		15	6	399	4
Coal	Fireclay Coal	0	4	399	8
Batt		2	0	401	8
Coal		2	10	404	6
Pricking		0	5	404	11
Coal		0	9	405	8
Measures		32	6	438	2
Green rock		13	0	451	2
Measures		28	0	479	2
Deep Coal		4	0	483	2

Further details as to the depth to the seams elsewhere in the area are given in the records of Colliery Sections (Appendix No. 1, p. 242).

West of the Mitre Fault.

At Bridgtown the Mitre Fault has a downthrow west of not less than 500 ft. Its course further north cannot be traced under the Trias and Drift; but east of Huntington a fault with a downthrow west has been proved in the Deep Coal. The direction of the line of this fault is slightly east of a line having the general direction of the Mitre Fault.

The shafts of the Littleton Collieries at Huntington are situated on the downthrow side, but particulars about the depths to the seams and of their identification is at present withheld. No. 2 shaft reached a depth of 1,642 ft. and No. 3 shaft a depth of 1,663 ft. The general inclination of the measures is to the west. Several faults are met with having an aggregate downthrow to the west.

Around Cannock the map shows an area of coal measures beneath Drift, whereas on the old map the same ground is represented as consisting of Bunter Conglomerate, but the brecciated character of the Bunter on Shoal Hill suggests an outcrop of the basal beds of this formation and that it does not extend far south of this point. No information is obtainable as to these concealed Coal Measures, and with the proved existence of faulting to the east and north it is not safe to speculate what part of the sequence lies beneath the glacial deposits.

South of Ridings Brook, at Bridgtown, the Etruria Marls come to the surface in the Longhouse Brick and Tile Works (p. 113). An old clay pit, 50 yards west of Long House Farm, shows red clay. Near here appears to be the site of the shaft of which Jukes (*op. cit.* p. 96) gives the following abstract of a section referred to in his note-book as that of the Waterloo Pits, Longhouse Colliery.

	Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Sandy rotch, red	35	6	—	
Grey clunch	4	0	—	
Reddish marl	28	10	68	4
Measures	73	2	—	
COAL and batt	1	9	—	
Rock and clunch	10	0	—	
COAL	2	5	—	
Parting	0	2	—	
COAL	1	8	—	
Parting	0	3	—	
COAL	1	4	—	
Clunch	1	11	—	
COAL	2	0	163	0
Measures	18	3	—	
Green and brown rock	49	0	—	
Clunch	7	5	—	
OLD ROBINS COAL	6	6	244	2

Down to a depth of 68 ft., the measures, except possibly for some Drift at the top, evidently belong to the Etruria Marls.

Between Bridgtown and Essington the Etruria Marls continue at the surface, but crop out before they reach No. 7 Pit of Hollybank Colliery, 300 yards south-east of Essington Church. At Cannock Old Coppice Colliery the Deep Coal lies at the depth of 774 ft., or 374 ft. below O.D., the Etruria Marls being penetrated to the depth of 246 ft. Between here and Warstone is a tract of unproved ground until the northern workings of Hollybank Colliery are reached.

As the shafts of this colliery prove nearly the complete succession of the Middle Coal Measures down to the pre-Carboniferous floor the sections, as proved at No. 5 (Mills Engine Pit of Jukes, *op. cit.*, p. 94) and No. 15 shaft, are given below.

Hollybank.

Section in No. 5 Shaft, Hollybank Colliery, Essington.
6 in. map Staffs, 57 S.W., Lat. 52° 37′ 30″ north,
Long. 2° 3′ 5″ west.
Communicated by Mr. J. C. Forrest.
Height above O.D., about 550 ft.

	Thickness. Ft.	Thickness. In.	Depth from Surface. Ft.	Depth from Surface. In.
Spoil	15	6	15	6
Red clay and sand (Glacial)	12	3	27	9
Measures	25	6	—	
Batt and COAL	2	0	55	3
Measures	36	9	—	
COAL	1	9	93	9

		Thickness.		Depth from Surface.	
		Ft.	In.	Ft.	In.
Measures		9	11	—	
Coal		2	8	106	4
Parting		0	9	—	
Coal		3	0	—	
Parting		1	0	—	
Coal		0	9	—	
Parting		1	3	—	
Coal		0	9	—	
Parting		1	6	—	
Coal		0	9	116	1
Measures		3	0	—	
Coal		1	2	120	3
Measures		66	3	—	
Coal and Batt		2	1	188	7
Measures		32	6	—	
Coal	Seven-Feet Coal	3	0	—	
Parting		0	2	—	
Coal		4	4	228	7
Measures		43	1	—	
Coal		0	10	272	6
Measures		13	4	—	
Coal	Robins Coal	1	0	—	
Parting		0	2	—	
Coal		4	6	291	6
Measures		6	3	—	
Coal		0	7	—	
Measures		28	4	—	
Coal	Yard Coal of Wyrley	3	0	—	
Parting		0	6	—	
Coal		1	6	331	8
Measures		15	5	—	
Coal		0	9	347	10
Measures		20	7	—	
Coal		1	3	369	8
Measures		11	3	—	
Coal, Charles' Coal of Wyrley		2	3	383	2
Measures		29	8	—	
Coal, Brooch (Cannel of Wyrley)		3	9	416	7
Measures		59	7	—	
Coal, Benches (Brooch of Wyrley)		2	2	478	4
Measures		3	6	—	
Coal		0	7	482	5
Measures		27	5	—	
Coal		2	0	511	10
Measures		44	5	—	
Coal	Eight-Feet Coal	5	6	—	
Parting		0	7	—	
Coal		2	6	564	10
Measures		48	8	—	
Coal, Four-Feet Coal (continued in No. 15 Shaft)		4	0	617	6
Measures		59	11	—	
Coal, Heathen Coal		2	2	679	7
Measures		58	1	—	
Coal, Stinking (Sulphur) Coal		1	6	739	2
Measures		23	6	—	
Coal, Yard Coal		2	7	765	3
Measures		28	4	—	
Coal, Bass Coal		1	9	795	4
Measures		53	9	—	
Coal, Cinder Coal		0	9	849	10
Measures		20	1	—	
Coal, Shallow Coal		8	11	878	10
Measures		8	9	—	
Coal, Deep Coal		4	8	892	3

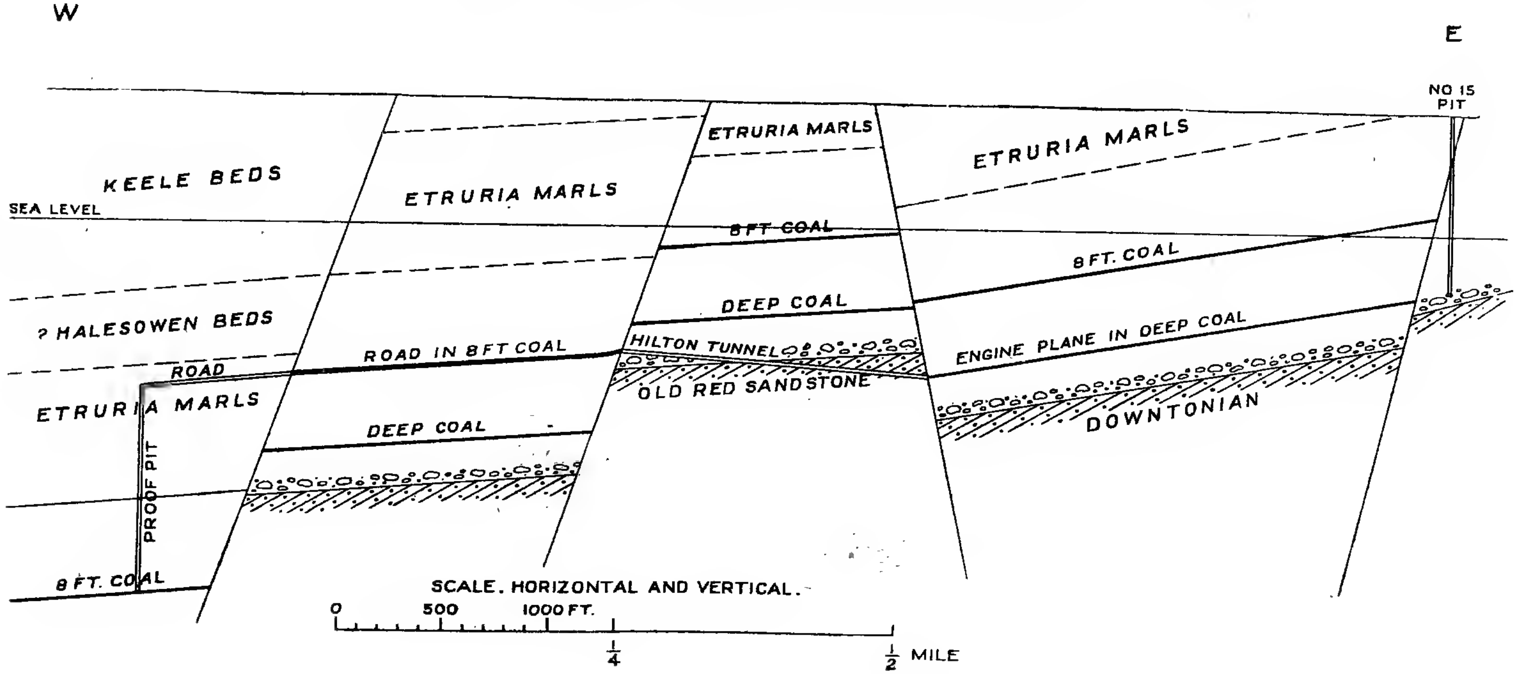
The shafts of No. 15 pit (599 O.D.) 160 yards, S.S.E. of No. 5 shaft, intersect the Mitre Fault and the Deep Coal occurs at a depth of 638 ft. from the surface on the up-throw side of the fault. The strata below the coal consist of:—

	Thickness.		Depth from Surface.	
	Ft.	In.	Ft.	In.
DEEP COAL	—		638	0
Pricking and fireclay	5	2	—	
Gubbin ironstone measures	6	0	—	
Rocky fireclay	3	0	—	
White rock and rock binds	20	6	—	
Binds with ironstone	8	0	—	
COAL		10	681	6
Fireclay	0	4	—	
COAL	1	0	682	10
Fireclay and rocky fireclay	4	2	—	
Rock and rock binds	7	2	—	
Binds with ironstone	9	0	—	
Brown rock	4	3	—	
COAL	2	10	710	3
Rocky fireclay	3	3	—	
Fireclay with ironstone balls	7	5	—	
Rocky fireclay with red streaks	5	1	—	
Black shale	2	1	—	
Fireclay with red streaks	2	2	—	
Black shale with peldon and balls	4	0	—	
Binds with ironstone	3	5	737	8
Rock binds	4	9	—	
Rubbly ground	2	3	—	
Strong red rock	11	0	—	
Strong white rock with beds of marl	8	6	—	
White rock	6	0	—	
Red marl	1	0	—	
White rock with beds of marl	5	7	—	
Blue rock	6	0	—	
COAL	1	0	783	9
Fireclay	2	0	—	
Reddish rock binds	5	1	—	
White rock with beds of marl	19	6	—	
Fireclay with red streaks	2	0	—	
Strong blue rock	6	0	—	
Conglomerate	9	0	—	
Hard white rock	2	0	—	
Dark rock binds	2	0	—	
Hard white rock	3	7	—	
Conglomerate	15	7	—	
White and blue rock (Base of Coal Measures)	3	0	853	6
Red marl with blue partings	19	0	—	
Blue rock	1	1	—	
Red marl with blue partings	14	1	887	8

The red beds below the depth of 853 ft. 6 in. have been discussed on p. 67. In the measures below the Deep Coal it will be observed that, as at Bentley, no workable coals occur, while the measures have expanded from 150 ft. at Bentley to 215 ft. at Hollybank.

The seams worked are the Deep, Shallow, Cinder, Four Feet, Eight Feet (Mitre Coal), Brooch, the seams yielding house, manufacturing and locomotive coal. The basal conglomerate is very coarse, some of the pebbles ranging from 6 to 8 in. in diameter and consisting of limestones, quartzites, and a fine-

Fig. 4.—Section through Hollybank Colliery.



grained light-coloured grit with abundant yellow spots, due to staining. In the workings the dip of the seams varies from 1 in 3 to 1 in 5 in a general S.W. direction. In addition to the Mitre Fault, two faults are found in the northern part of the workings, which die out before reaching No. 5 pit; the throw of these faults is to the east. Further west a second fault occurs, also with a down-throw east.

For some years the workings ended at the last-mentioned fault, nor was the amount or the direction of its throw known, and it was indeed for some time regarded as the Western Boundary Fault, with probably a large downthrow to the west. Subsequently a rock heading, rising 1 in 14, driven across this fault, encountered further west a fault of 150 yards down west, which brought the Eight Feet Coal on the west nearly against the Mealy Greys on the east. The Eight Feet dipping westerly at 1 in 9 was then followed, when disturbed ground was again encountered, and on the west side the heading entered the Etruria Marls. A proof shaft was started in the Etruria Marls 1,415 ft. vertically beneath a point 1,000 yards N.W. of Essington Church (on the extreme western margin of Sheet 154). The shaft was continued in the Etruria Marls for 480 ft. when the grey Middle Coal measures were entered, and, the Eight Feet Coal at a depth of 987 ft. down the shaft, or 2,402 ft. beneath the surface. The Eight Feet Coal has been shown to be here dipping south-west at 1 in 10. Thus the general direction of dip is maintained, but its amount is much less than in the workings east of the fault. The throw of the last-proved fault, called 'The Western Boundary Fault,'[1] is estimated at 1,050 ft. But whether this is the last of the westerly downthrow faults remains to be proved.

Igneous intrusions of the same type as those of Pouk Hill (p. 198) are met with in the workings. Specimens (Nos. 9636, 9638-40) examined by Dr. H. H. Thomas show that the dominant rock is a dark grey ophitic olivine-dolerite with analcite. When accurring in the coal the igneous rock is pale coloured, and becomes known as "White Trap." A specimen (No. 9637) intrusive in the Deep Coal, is reported on by Dr. H. H. Thomas (p. 200). It is noticeable that the coals are only slightly affected by the intrusions.

THE BENTLEY TROUGH AND SOUTH.

That two parallel faults trending east and west and enclosing a trough, traverse the coalfield between Walsall and Short Heath was determined by Jukes (op. cit. p. 167) from an examination of mining plans then available. The southernmost of these faults was estimated to throw down north to the amount of 360 ft., and another fault parallel to it about ¼ mile farther north was calculated to have a throw of 75 ft. down south. At the present day mining operations have ceased entirely and the surface is thickly strewn with debris. Old plans show a fault of 285 ft. downthrow north, near North Walsall Station, increasing to 366 ft. on the north side of Reeds Wood Park. Further west at Lanehead a shaft is now getting the Bentley Hay (Top Four Feet) Coal at 36 ft. depth. The New Mine Coal, rising north at 3°, crops out half a mile to the south, so that the Fireclay Coal should be at or near the surface on the upthrow side of the fault at Lanehead Bridge. The fault then will here possess a throw of about 200 ft.

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[1] N. Forrest, 'Description of the Proof of the Western Boundary Fault at Holly Bank Colliery.' *Trans. Fed. Inst. Min. Eng.*, Vol. 47, 1913–14, pp. 360–384.

Particulars about the throw of the northern fault are wanting, and whether the two faults die out west of Ashmore Lake or continue and join the Mitre Fault is not known.

In the east side of the trough the measures rise to the east and conform in strike with the country outside the trough. On the west side, however, the measures within the trough rise due west at 1 in 10 and the strike is at right angles to the adjacent country on the south and north. The Bentley Faults therefore appear to indicate a torsion of the strata and it is significant that the chief intrusions of igneous rocks occur in their proximity.

The character of the strata and depths to the seams towards the deepest part of the trough are given in a MS. record of the Victory Engine Pit collected by J. B. Jukes, situated near the northwest corner of Reeds Wood Park. On the west side of the trough the shafts of the old Lanehead Bridge Colliery, east of Lanehead, reached the Fireclay coal at a depth of 248 ft., and then proved the following section:—Black ground 5 ft. 6 in., green rock 32 ft., black ground 5 ft., green rock 24 ft., rock and fireclay 10 ft. 6 in., Bottom Coal 4 ft. 2 in.

The effect of the Bentley Fault as pointed out by Jukes (*op. cit.* p. 163), is considerable from an economic standpoint. West of Walsall the general north and south strike of the measures gradually takes on an east and west direction with a rise to the north, sufficient if continued to bring the Bottom Coal to the surface north of Pouk Hill, whereas the whole of the workable coals are brought in by the fault over the northern part of the South Staffordshire Coalfield.

The line of the Bentley Fault also forms the northern boundary of the area under the South Staffordshire Mines Drainage Act.

To the south (upthrow side) of the Bentley Fault the Bottom Coal crops out in the bottom of the valley west of Reeds Wood Park, and though now hidden under spoil it keeps to the east side of the valley up to a point due west of the Moat where, according to Jukes (op. cit. p. 165) it is thrown down to the south by a fault of 120 ft. throw just south of the Moat. At James' Bridge Colliery, ¼ mile S., the seam is 90 ft. from the surface. Westwards, towards Willenhall, the general inclination of the measures is to the S. and S.W. with the Bottom Coal gradually rising northward but never quite reaching the surface. Limited areas of this coal and of the ironstones below remain ungotten on Bentley Heath and around Willenhall.

The New Mine Coal crops out near the Monmore Lane Ironworks south of Ashmore Lake but around Willenhall and to the south this coal and those beneath have been almost exhausted.

Upper Coal Measures.

By W. Gibson.

INTRODUCTION.

Nowhere is there a complete sequence, and the relationships of the Etruria Marls, Halesowen Sandstones and Keele beds cannot be made out.

The Etruria Marls consist of red and mottled marls with occasional lenticular bands of green grits ('espley rocks'). On the eastern side of the coalfield they are nowhere seen in normal superposition on the Middle Coal Measures; but in the record of the Aldridge sinking (p. 227) they appear, from the description of the beds, to pass down into the Middle Coal Measures, and a similar passage is well seen at Littleworth Tileries on the western side of the coalfield. The top beds are nowhere exposed, being faulted out or concealed under the Trias. The Halesowen Sandstones are composed of yellow, grey and white sandstones, shales, and clays. They are nowhere seen in normal contact with the Etruria Marls, and, at about 30 ft. below their top, appear to pass upwards into the Keele Beds. They contain a seam of coal 15 in. thick. No bands of Spirorbis limestones and no determinable plant-remains have been found. The Keele Beds are found on the eastern side of the district, but are not clearly exposed. They consist mainly of bright red marls, with impersistent bands of sandstone, usually calcareous; some of these sandstones are fine-grained and flaggy, and purplish in colour, while others are coarser and of a yellowish brown or brick-red colour. One or more bands of Spirorbis limestone have been detected.

Local Details.

Etruria Marls.

Near Littleworth, in the northern part of the district, the lower beds of the Etruria Marls are clearly exposed in the Brick and Tile Works at Littleworth, N.E. of Cannock, where the following section was obtained at the western side of the excavation:—

		Ft.	In.
Glacial ...	Sandy clay with streaks of contorted sand	4	0
	Coarse sand with pebbles	3	0
Etruria Marl ...	Red marl	30	0
	Dark purple and mottled marl ...	15	0

Grey coal measures, slightly mottled, form the floor of the pit. The glacial drifts thicken to the west, but there is little doubt that they rest on the red clays as far west as East Cannock Colliery; for here, beneath 66 ft. of glacial sand and clay the shaft of No. 2 Pit entered strata 63 ft. thick, described in the record as red, brown, and purple marls, the lowest bed of red clay being 225 ft. above the Old Man's Coal and 1,032 ft. above the Deep Coal. That the Etruria Marls occupy only a narrow belt is proved by the shafts of the Wimblebury Pits, Cannock Chase Pits No. 9, West Cannock

Pits, and those of the Pool Pits, both of which enter grey measures immediately below the Trias.

On Rumer Hill, about one mile S.W. of East Cannock Colliery, red clays, identical with those of Littleworth, were formerly worked for bricks on Rumer Hill, east of Cannock. These shallow excavations are now nearly water-filled, and the red clays are no longer visible. They are said to rest on a coal, 3 ft. thick, lying not less than 900 ft. above the Deep Coal. The area occupied by the red clays is practically limited to the excavations, and only to the south-west is there any possibility of their extension.

Around Cheslyn Hay and Essington, between Bridgtown and Essington, the Etruria Marls form a continuous though narrow outcrop on the downthrow side of the Mitre Fault (p. 98), and owing to the nearly complete absence of glacial drift they have been excavated in several places for brick-making, etc. The lowest beds are those exposed in the Longhouse Clay Pits on the north side of the canal at Walkmill Bridge. Consisting chiefly of mottled marl, the following general descending sequence occurs along the south side of this extensive excavation:—(1) Mottled red marl, 40 ft.; (2) deep purple and black marl, 1 ft.; (3) mottled red and ochreous marl, 100 ft.; (4) red mottled marl, 40 ft.; (5) black shale and coal, resting on fireclay, 1 ft.; (6) deep red marl. Lenticular bands of espley rock, weathering deep brown and reddish, occur at intervals. The beds are highly though irregularly inclined to the west, up to as much as 60°, and owing to their proximity to the Mitre Fault, are much disturbed. On the south side of the canal, in a pit 100 yards to the west, and therefore in higher beds than those at Longhouse, the clays are much sandier and mainly deep red, with only a little mottling. They are inclined west at 25°. Some trial holes further west have proved similar red marls close up to the outcrop of the Bunter. The total thickness of the marls exposed amounts to about 600 ft. without the summit or base being seen. Between Walkmill Bridge and Cheslyn Hay the marls, containing lenticles of espley rock, are excavated at the Rosemary Hill Tileries, and were passed through in the shafts of the Cannock Old Coppice Colliery to the north-west. From here southwards to Essington the country is drift-free, the soil consisting everywhere of stiff red or crimson clay. Openings occur near the west side of Cheslyn Hay and in the disused Hollybush Tileries 350 yards to the west. In each a deep red, soft micaceous sandstone is seen resting on purple ochreous clays. The two sections are identical and strongly suggest a repetition by faulting, as is reasonably possible, regarding the many faults heading for the area proved in the coal-workings to the north and south. The sandstones strongly suggest those seen on the eastern side of the coalfield at Walsall Wood (p. 115). On the First Edition (1852) of the map, Jukes placed the beds in the Permian: but on the Second Edition (1859), while he included the beds at Cheslyn Hay in the Coal Measures, those of the Hollybush Tileries are still retained in the Permian, the western boundary fault being represented as passing between the two sites. The deep crimson-coloured clay soil and an occasional exposure in the sides of ponds enables the outcrop to be traced southward to Holly Bank, where ochreous, purple, and mottled marls, with lenticular bands of espley rock are seen to a depth of 60 ft. in the Essington Brick Pits near the main road to Essington. The dip here is obscure, but in the coal-workings beneath it is 12°, directed west 20 north, which is sufficient to cause Etruria Marls to crop out to the south before No. 7 Pit of the Holly Bank Collieries is reached. The incline of this colliery driven across the measures and the proof shaft sunk to the 8 ft. coal at the western extremity of the incline show that the Etruria Marls are at least 540 ft. thick under the Trias of Hilton Park (Sheet 253). W. G.

On the eastern side of the South Staffordshire Coalfield, the Etruria Marls, though they do not come to the surface anywhere north of Brownhills, have been proved beneath the Triassic cover at several points.

The most northerly place is adjacent to the eastern boundary-fault (p. 163), midway between Beaudesert Hall and Castle Ring. Here a heading has been driven through the fault from the Deep Coal workings of the Brick Kiln Pit (Brereton Collieries) at a level of about 17 ft. below O.D. (730 ft. below the surface). The heading got into red marls, which, from specimens preserved by Col. R. S. Williamson, appear to be referable to the Etruria Marls.

Between Red Moor and Chase Terrace the Cannock Chase Colliery workings[1] have shown at two points that red marls are thrown down along the boundary-fault (p. 164) to a position level with the Deep Coal. These points are situated 100 yards and 400 yards respectively south of the Rawnsley road between Red Moor and Chase Terrace. At the first, a cross-measure drift entered red measures 15 ft. below O.D.; at the second, a heading from the Deep Coal struck red measures at 64 ft. below O.D. Half a mile farther south a heading, driven through the fault at a point situated 220 yards north-east of the upcast shaft of the Cannock Chase No. 5 Pits at Chase Terrace, passed into red marls, clays, and sandstones, which, from specimens preserved in the colliery office by Mr. S. F. Sopwith, appear to be Keele Beds, but are probably Etruria Marls.

At Brownhills the Etruria Marls emerge from below the Triassic cover, and, forming a strip between the Clayhanger Fault (p. 165) on the west, and the Vigo Fault (p. 167) on the east, extend southward as far as Aldridge. At the northern extremity of this tract the beds are concealed by Glacial drift; but in the northern angle included between High Street and Brick Kiln Street, Brownhills, the traditional site of some brick-works may indicate that the marls were once worked here below a thin cover of gravelly boulder-clay. At Clayhanger this drift thins away, and thence southward the red Coal Measure clays are exposed in shallow excavations and old clay-pits.

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[1] A. Sopwith, 'The Northern Part of the South Staffordshire Coal-Field,' *Trans. Fed. Inst. Min. Eng.*, vol. iii (1891-2), p. 50 (1892).

At Walsall Wood Colliery two deep clay-pits have been excavated for brick-making. The northern and shallower one, now disused, shows about a foot of gravelly drift on 5 ft. of red sandy marl, over red and lavender-tinted sandstones, exposed to a thickness of 8 ft. The material taken from the southern pit,[1] 100 yards to the south-west, between the mineral railway and the canal, produces pale-red and yellowish-red bricks and drain-pipes, but will not yield blue bricks. The pit shows in descending order (1) 18 ft. of red sandy marls, (2) 10 ft. of soft dark-red sandstone, with a thin and impersistent band of conglomeratic cornstone ('pellet-rock') at the top, and (3) 15 ft. of dark- and light-red 'fish-eyed' marls. All the marls in the pit show lines of green mottling, and numerous small green decolouration-spheroids ('fish-eyes'); the cornstone is highly calcareous. The beds dip westward at 4°. A small sand-pit, 70 yards south of the colliery-office, showed in 1911, under 2 ft. of gravelly drift, red soft sand-rock, exposed for 7 ft.; and the colliery-shafts, close by, proved, above the productive measures, a thickness of 308 yards of beds of which the dominant colour is red, though the records are not sufficiently explicit to determine whether these were Etruria Marls or Keele Beds.

The beds exposed in the clay-pits and in the sand-pit have a close resemblance to parts of the Keele group. They are, on the whole, paler in colour than the Etruria Marls typically exhibited in the Aldridge clay-pits farther south, and are not sufficiently rich in iron oxides to produce blue bricks; they contain none of the espley-rocks characteristic of those marls, while the cornstone-band is similar to those in the Keele Beds. There are strong grounds, therefore, on which to assign the beds in question to a part of the Keele subdivision, perhaps faulted in among the Etruria Marls. But the featureless character of the ground, and the absence of any record, in the shaft-sections, of beds that can be regarded as Halesowen Sandstones, have led us to include these exposures at Walsall Wood Colliery under the Etruria Marl colour on the map.

Three-quarters of a mile to the south-west, red clays have been worked for bricks at Goblin's Pit Farm (now Grange Farm), and red clay is exposed in the cuttings on the Midland Railway both north and south of Walsall Wood Station; but whether the clay should be assigned to the Keele Beds or to the Etruria Marls there is not sufficient evidence to show.

A little farther south, however, we reach more definite ground, opened up by the group of deep open excavations at the well-known blue-brick and tile works lying between Vigo and Stubber's Green, in the parish of Aldridge. These clay-pits, several of which are nearly 100 ft. deep, exhibit the Etruria Marls in their typical aspect. The prevailing material is a dark-red, hard marl, in which subordinate bands of purple and green coarse gritty sandstone and breccia ('espley rock') occur at intervals. The pebbles in some of these espley-bands range up to 3 in. in length, and consist chiefly of quartzite; others appear to be ashy. The following measurements of Messrs. Joberns's pit[1] will serve as a type of the whole group of excavations:—

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[1] Survey Photograph No. 1539.

	Ft.
Glacial gravelly boulder-clay, 4 ft. to... ...	11
Clay (weathered marls, 'grummel'), 8 ft. to	10
Espley rock (rejected), 6 ft. to	8
Red marl, 12 ft. to	10
Espley rock (rejected), 4 ft. to	5
Red marl (with thin layers of rock 1 to 3 ft. thick) in pit and sump, about	50
	94

Some of the green spheroids ('fish-eyes') from the marls in this pit are said to have been found by Sir Wm. Crookes to contain traces of vanadium. In several of the pits some of the marl-bands have a mottled yellow, pink, magenta, and green colour. The prevalent dip in these pits is more or less northward at angles varying from 0° to 5°.

The shafts of the Aldridge, Leigh's Wood, and Coppy Hall Collieries have been sunk through these Etruria Marls to reach the productive measures below; at the first-named, 166 yards of Etruria Marls were proved; and at the second, 120 yards. At Coppy Hall the thickness was found to be at least 72 yards; but possibly an additional thickness of 47 yards should be included.

The recent explorations of the Aldridge Colliery have shown that the Etruria Marls extend eastward underground beyond the boundary-fault, and are present below the Trias and Keele Beds of Upper Stonnall. The results of this trial will be discussed in Chap. viii, p. 169.

Farther south, in the angle between the Walsall Wood and Walsall branches of the Midland Railway, near Aldridge Station, the Victoria Colliery was sunk as the Aldridge Trial Pit[2] about 1849. Jukes records at the top of the shaft 43 ft. of Glacial drift (soil, sand, and loam), the beds below being grey and dark fireclay, clod, binds, etc., and coals, all belonging to the productive measures. It seems, therefore, that none of the measures in this pit can be referred to the Etruria Marls, and, in consequence, on the map the base of this subdivision has been drawn a few yards north of the colliery. But south of the railway, at Pool Green, a small triangular area, included between the Clayhanger Fault on the west and the Vigo Fault on the east, seems to consist of red clay, presumably Etruria Marls; and to account for their occurrence here a southerly downthrow along the railway has been drawn upon the map.

THE HALESOWEN GROUP.

South of Aldridge the Halesowen Sandstones, which form a narrow strip, nowhere more than 120 yards wide, between the Silurian rocks on the west and the Keele Beds on the east, extend from Barr Common to Daisy Bank. The western margin is faulted along its whole length; the eastern one appears to be a normal junction with the Keele Beds.

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[1] Survey Photograph No. 1538.

[2] Jukes, *op. cit.*, ed. 1, pp. 231-2; ed. 2, pp. 99, 160. *See also* Vert. Sect., Sheet 16, No. 4.

At the northern extremity of their outcrop the beds were many years ago tried for coal at a small shaft still to be seen 550 yards east of Aldridge Lodge. This trial appears to be the one alluded to by Jukes[1] as a "pit between Aldridge Lodge and Hill End"; it is said to have been 62 yards deep and to have proved three beds of coal and two of ironstone; the measures dipped east-south-east at 25°, as is indicated on the old map (62 S.W.) by an arrow. The tip is now grassed over, but it shows signs of grey shale, fragments of ironstone, and coal.

A ditch alongside a footpath at the northern end of Cuckoo's Nook Wood (west of Longwood Cottage) shows yellow clay soil with lumps of ironstone characterized by 'grub' structure (p. 77); while 100 yards farther south the western boundary-ditch of the wood shows a coal-smut in grey clay. At 300 yards south of the wood an old shaft-tip contains pieces of grey sandstone, clay, ironstone, and fragments of coal. At the Three Crowns a field on the south-eastern side of the Walsall-Streetly road contains the sites of three small shafts, said to have been sunk about 1845, of which the scanty refuse-heaps show grey clay with pieces of ferruginous sandstone, ironstone, and coal.

About 400 yards south-west of the Three Crowns a gully leads down from the roadside and passes from the base of the Keele Beds across the outcrop of the Halesowen Sandstones onto the Silurian rocks at Daffodil Farm (p. 16). The section shows that the upper beds of the Halesowen Sandstones are faulted against Silurian on the north-west and dip normally under the Keele Beds on the south-east. They contain a 15-in. coal, probably the one once worked in the pits already mentioned. Some of these Coal Measure sandstones were mistaken on the old map for an outcrop of Upper Llandovery Sandstone.

Opposite Daisy Bank this narrow outcrop of the Halesowen Sandstones runs out to a point between the fault on the west and the Keele Beds on the east; but another outcrop of beds that appear to belong to the same subdivision of the Upper Measures comes in south-east of Gillity Greaves (a quarter of a mile south-west of Daisy Bank) and passes out of the map into Sheet 168. This tract is included between the continuation of the boundary-fault and a branch fault which, farther south, usurps its function. In this outcrop no sections are exposed, but pieces of white and pale-yellow sandstone, containing Stigmaria and other plant remains, are abundantly scattered on the fields.

KEELE GROUP AND THE HAMSTEAD BEDS.

Along the eastern side of the coalfield, although the Keele Beds do not reach the surface anywhere north of Brownhills, their presence under the Triassic cover at Ogley Hay was revealed in 1911 by the explorations of the Walsall Wood Colliery. The results of this attempt to surmount the eastern boundary fault will be discussed in Chapter viii, p. 167.

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[1] *Op. cit.*, ed. 1, 1853, p. 269; ed. 2, 1859, p. 160.

At Brownhills the Keele Beds crop out between the Bunter Pebble-Beds on the east and the Etruria or Aldridge Marls on the west, and, widening southward, extend as far as Aldridge, south of which place another outcrop, beginning as a narrow strip at Pool Green, rapidly expands and ultimately passes out of the map into Sheet 168.

The northern end of the outcrop is much obscured at Brownhills by Glacial drift; but south of the Walsall-Lichfield road, at Shire Oak Hill, occasional small sections are afforded by old quarries and marl-pits. In one of these, 300 yards south-west of Old Shireoak Farm, pieces of pale-red fissile fine-grained calcareous sandstone, characterised by 'fish-eyes,' occur in a red clay soil. A well at a cottage 250 yards north of Castle Gate (3 furlongs along the Stonnall road from Vigo) was sunk in red marl and hard red sandstone; while yellowish-brown sandstone has been got at a shallow excavation 100 yards farther west.

On the top of Holly Bank, close by to the south-west, some old sand-pits, in which coarse bright-red sand with marl-bands is poorly exposed, appear to be the sections indicated by a dip-arrow on the old map (62 N.E.), while some red and yellow sand-rock is to be seen in an old pit in a garden 200 yards to the south-west. These sections were shown on the old map[1] as lying on an extensive area of Upper Mottled Sandstone (Bunter), to which the beds bear a close resemblance; and to account for the presence of the Trias in such a position, two powerful faults were introduced. But even if the sections in question should rightly be assigned to the Upper Mottled Sandstone, the faults introduced to account for them throw into Bunter much ground that must clearly be referred to the Keele Beds. Moreover, the faults as drawn, not only disregard some well-marked surface-features, but are unsupported by the evidence of some recent colliery explorations. The sandstones exposed on Holly Bank appear to be associated with marls, and are also not unlike some red sandstones that crop out in the Keele Beds a little farther south. Taking all these facts into consideration, we have decided to include the debatable ground in question within the Keele outcrop.

About 300 yards east of Castle Gate a roadside section in light-red and yellow sandstone, dipping north-east at about 20°, sufficiently shows the character of this sandy upper part of the sequence.

A little farther east still higher beds, forming part of the Hamstead group, are exposed in and south of Castlebank Plantation. At the northern end of this wood an old clay-pit shows debris of pink soft marl, and pieces of fine-grained red sandstone characterised by 'fish-eyes.' Immediately south of the road forming the southern edge of the wood an old overgrown quarry shows in descending order: (1) calcareous red sandstone, 3 ft.; (2) marl debris, 4 ft.; (3) calcareous red sandstone with marl parting, 7½ ft.; (4) conglomerate, very coarse, 1 ft. Many of the sandstone beds are fine-grained and 'fish-eyed.' The beds in the quarry have a high dip (about 35°) in a south-eastward direction, toward the Bunter Pebble-Beds, which are thrown down against the Keele Beds by a fault, along which the quarry ends.

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[1] *See also* Horiz. Sect., Sheet 23, No. 5.

Similar beds at much the same horizon have been quarried 200 yards farther south, where again they dip steeply at 55° toward the south-east, and are in that direction immediately cut off by the fault that throws down the Bunter. Here the following section is exposed:—

	Ft.
Sandstones, red, yellow, and whitish, of varying texture and hardness, and containing small pebbles of red and of yellow chert, which near the base form a thin conglomerate	6¼
Beds obscured for	8
Conglomerate, coarse, chiefly of Carboniferous chert pebbles	10
Marl, red	4
Sandstone, calcareous, yellow	4

The conglomerate is in places very coarse and contains rounded and subangular pebbles, which in some cases reach 6 or 7 in. in diameter. These pebbles include red, yellow, and grey chert, crinoidal white limestone, brown sandstone apparently of Keele derivation, vein-quartz, and yellow and red marl in the form of small pellets. Of these the cherts are the most abundant, and form a very marked feature of these beds; they contain cavities left by the dissolution of crinoid ossicles, and there can be no doubt that they are derived from the Lower Carboniferous formation, which also furnished the limestone pebbles. The matrix of the conglomerate is coarse and sandy, and contains a very large amount of calcite.

The sandstones are massive and false-bedded, and when fresh have a hard calcareous cement. In this state they were formerly quarried for building-stone, and Stonnall church is said to have been built of stone quarried here. But, in weathering, they rapidly lose their calcareous matter and become friable, in which condition they are in some cases indistinguishable from Bunter sandstones. C. H. C.

Between Vigo and Druid's Heath, only three sections call for special notice. Immediately east of the fault that forms the western margin of the Keele Beds at Vigo, a brook-section, 100 yards east of King's Hayes Farm, shows, embedded in red marl, a lenticular mass, 18 in. long, of grey Spirorbis limestone, surrounded by grey marl. The limestone yielded *Spirorbis pusillus* (Mart.) and ostracods. In the brook occur pieces of brown and red calcareous sandstone of typical Keele characters.

At a somewhat higher horizon a sand-pit, 400 yards south-east of the same farm, shows 10 ft. of red, brown, and brownish-yellow sand-rock, with some thin marly bands. The beds appear to dip north-eastward at 10°. The sand-rock has yielded a few small subangular pebbles of quartzite, sandstone, chert, tuff, and clay-ironstone. The presence of these pebbles suggests that the beds belong to the Hopwas Beds forming the base of the Bunter

Pebble Beds (p. 122). But the occurrence of some red marl, especially that at the north-eastern end of the pit, and the fact that a little digging in the floor of the excavation towards the same end showed that the red sand-rock in the sides of the pit is underlain by similar material, but having the lavender colour characteristic of sandstones in the lower part of the Keele group, show that if the material dug for sand is Bunter, it must form an outlier of very small dimensions.

About 350 yards east of this pit, and separated from it by what appears to be red marl ground, an old marl-hole shows a few feet of soft fine-grained bright-red sand-rock in the eastern bank, presumably overlying the red marl exposed in the same bank a few yards farther north. The sandstone closely resembles that of the Bunter. But if it belongs to an outlier of the Hopwas Beds, its limits are not recognizable, and it is separated from the sand-rock, dug in the pit last described, by red marl, exposed in an old excavation in a thicket between the two pits.

Between Druid's Heath and Aldridge an old pit within the south-eastern angle of Leigh's Wood (south-west of Pennard House) shows signs of having been dug in red marl. Between the wood and the Midland Railway at Leigh's Wood Colliery another old pit shows red clay, pieces of calcareous fine-grained red sandstone with 'fish-eyes,' and lumps of brown and yellow calcareous conglomeratic cornstone or 'pellet-rock' (p. 53). Southward, toward Pool Green, the hedge-banks and one or two old marl-pits show that the prevailing type of rock in this part of the Keele group is red marl.

In the southern outcrop, south of Pool Green, little more than red clay in the hedge-banks is to be seen till we reach Birch Wood (the northern of the two woods half a mile north of Pool House), in the north-western corner of which the tip from an old trial-shaft, sunk presumably for coal, shows nothing but red marl.

South of the Walsall-Streetly road three or four lenticular bands of limestone-conglomerate make their appearance in the middle of the outcrop of the Hamstead Beds, and have been laid down on the map. Above these the dominant type of sediment seems to be red marl; below them, red marls with some sandstones prevail. The lowest beds are visible in the gully south-east of Daffodil Farm (p. 16), where they appear to pass downward into the Halesowen Sandstones (p. 117). The junction in question crosses the northern branch of the gully about 11 yards above a fork in the stream, immediately adjacent to the lane leading from the Three Crowns to Daisy Bank and the Skip. The Halesowen Sandstones are followed without visible break by soft red marls, which presumably are the basement beds of the Keele group. These marls show pale-blue mottling, and contain some bands of yellow hard ferruginous rocky marl. All the beds appear to dip E. 30° S. at about 50°, and if this dip prevails south-eastward, there is room for 600 ft. of beds between the base of the Keele group and the lowest band of limestone-conglomerate.

There is evidence that a band of Spirorbis limestone crops out a little east of the base. A block of grey limestone, lying in a ditch 180 yards south of the Three Crowns, yielded *Spirorbis pusillus* (Mart.). Half a mile farther to the south-west, and 120 yards south-east of Daisy Bank, what is probably the same band seems to have been cut through in a marl-pit (now ploughed over), in which a small piece of similar limestone containing *Spirorbis* and ostracods was found, associated with debris of lavender-coloured and red calcareous sandstone.

Between this limestone and the conglomerate group of the Hamstead Beds, though red marl prevails, some low ridges and occasional debris show that bands of calcareous sandstone, red, brown, and green-speckled, are present, but none has been quarried.

The conglomerates themselves are impersistent, and, though they can be traced by low ridges along which the soil, where arable, contains abundant small pebbles of red and yellow fossiliferous chert and limestone, and lumps of pebbly, highly-calcareous sandstone, the absence of clear sections prevents our estimating their individual thickness. An old pit on one of these conglomerates, 500 yards south-west of the Pool House, though it shows no section, yielded a small piece of reddish-grey concretionary limestone (cornstone).

In the higher beds occupying the eastern part of the outcrop, between the Pool House and Barr Beacon, no conglomerates have been seen, and several old marl-pits show the character of this part of the sequence. An abandoned brick-pit, 440 yards south-east of the Pool House, at which an unsuccessful attempt was made to produce blue bricks for use at the adjacent reservoir, shows red clay, pieces of 'fish-eyed' red sandstone, and lumps of grey sandstone, derived from thin bands in the marls.

T. C. C.

CHAPTER VI.

PERMIAN ROCKS?

THE HOPWAS BRECCIA.

GENERAL ACCOUNT.

By G. BARROW.

Over much of the area here described a small group of breccias and sandstones occurs between the Carboniferous rocks and the Bunter Pebble-Beds. It does not form a continuous outcrop, but though nearly 100 ft. thick in places may be absent near by. That its absence is due to erosion is shown by the fact that the highest beds are generally the first to be lost. The group has not been affected by pre-Triassic movements, and rests on the Carboniferous rocks with as marked an unconformity as does the Trias in its absence. These relationships of the breccia to the formations above and below were recognised by Mr. C. J. Gilbert in 1890.[1]

Breccias are of frequent occurrence at the base of the Trias. An example near Polesworth (in Sheet 155) was described in 1889 by Mr. H. T. Brown,[2] and its identity with certain breccias in the Leicester Coalfield recognised. It was supposed to be allied to the Arley Conglomerate, which at that time was regarded as Permian, but it is now known that the Polesworth breccia rests unconformably upon the Keele Beds.[3]

In Leicestershire breccia has been identified at outcrops and in several borings and shafts. It was described in the memoir on that coalfield as Permian (that is, later than the Keele Beds) with the warning that it should possibly be correlated with the Trias rather than with the Permian.[4] It rests on Middle Coal Measures.

In North Staffordshire breccia at the base of the Bunter lies upon a low part of the Middle Coal Measures,[5] but at Streetly it rests on beds some thousands of feet higher up in the Carboniferous series. These breccias therefore behave as do the Permian breccias of the south-west of England and the brockram of the north-west, but their relation to the Magnesian Limestone series is nowhere apparent.

In connection with these breccias attention may be recalled to the pellet-conglomerates and pseudo-breccias of the Upper Coal

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[1] 'The Geology of Sutton Coldfield' (read before the Vesey Club and privately printed). *See also Geol. Mag.*, 1918, p. 232.

[2] 'On the Permian Rocks of the Leicester Coalfield.' *Quart. Journ. Geol. Soc.*, vol. xlv, 1889, p. 1.

[3] As shown on the six-inch MS. maps in the Library of the Geological Survey.

[4] 'The Geology of the Leicestershire and South Derbyshire Coalfield,' *Mem. Geol. Surv.*, 1907, p. 56.

[5] 'The Cheadle Coalfield,' *Mem. Geol. Surv.*, 1903, pp. 55, 56. Later examination has shown the identity in character of the calcareous breccia there described with the Hopwas Breccia.

Measures (pp. 48, 53) which show that a foreshadowing of breccia-conditions was manifest in Coal Measure times. At the same time it is noteworthy that similar conditions occurred in the Severn Valley at intervals extending well into later Triassic times.

This breccia was first met with in the district under description in a gravel-pit close to the canal on the north side of Hopwas, but its relationship to the Bunter is obscured by a thick cover of gravel with an uneven base, as well as by small faults and landslips.

In the Hopwas area when the breccia reaches its greatest thickness the highest part consists of a breccia, in one or more bands, with a calcareous matrix in which well-rounded pebbles of Carboniferous Limestone are abundant; at Hopwas these pebbles form about 40 per cent. of the medium and larger sizes of included fragments. With rare exceptions all the other stones are subangular or angular, and some appear to be wind-worn. The fragments occur in approximately the following proportions:—

	Per cent.
Limestone-pebbles	40
Quartzite, fairly fine and almost free from felspar	6
Quartzite,* small amount of felspar	9
Quartzite,* much felspar	15
Coarse quartzose rock,* felspar variable ...	4
Hard sandstone, red to grey and mainly Silurian ?	9
Vein-quartz	3
Augen-gneiss	1
Chert ?	4
Soft sandy marl	1
Ironstone-nodules (derivative)	2
	94

Of the quartzites marked * a considerable number contain minute specks of emerald-green chlorite, showing that all three were probably derived from the same rock-mass originally. The hard sandstones seldom resemble Carboniferous, but are probably in the main Silurian; some may be Cambrian. There are in addition about 5 to 7 per cent. of igneous rocks greatly decomposed.

Below the breccia are reddish-brown calcareous sandstones, all readily decomposing to a brown sandy loam. In them smaller subangular fragments occur both along lines and in small lenticular patches, but limestone-pebbles are less common and in places absent. These characters are maintained over a considerable area, but to the south-west the limestone-pebbles become scarce, and near Sutton Coldfield (Sheet 168) the commonest constituents are angular pieces of greyish coarse quartzite, decomposed igneous rock and fossiliferous Silurian sandstone.[1] This change marks an approach to the character of the Clent Hill Breccia which also immediately underlies the Bunter, but the relation of the two breccias is left open for the present.

The total thickness of the Hopwas Breccia has been proved to be nearly 100 ft. at Four Oaks. It is considerably less at the foot of the Bunter escarpment in the Barr Beacon area (p. 129).

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[1] Summary of Progress for 1912, *Mem. Geol. Surv.*, 1913, p. 29.

LOCAL DETAILS.

Hopwas Area.—The breccia and sandstones outcrop naturally from beneath the Bunter at the north end of the Hopwas Woods on the west side of the canal, and continue as far as Hopwas village, but everywhere are covered by downwash. Three excavations made in the bank-side afford good sections. The most northerly is an old quarry concealed in trees on the edge of the canal about the middle of the wood-side. Its position near the base of the Pebble-Beds is obvious, but at the top of the excavation there is a thin bed of red marl which may belong either to the Hopwas Beds or to the Bunter. Immediately below this the breccia occurs in two beds each about 7 ft. thick with a thin parting between. The matrix is coarse and markedly calcareous—almost crystalline—owing to the large amount of calcite in it. The limestone-pebbles are abundant, all well-rounded, and some 7 in. long. Many are coarsely encrinital, while some are compact and contain fossils proving their Carboniferous age. All the other included fragments are angular or subangular, and identical with those from the Hopwas pit.

The breccia is underlain by 12 ft. of rather soft red-brown sandstone, the base of which is not seen, and the sandstone occurs in three thick beds, all calcareous. Fragments are included, either along lines or in small lenticular patches, but they are noticeably smaller than those above, and limestone-pebbles are scarce.

The next excavation is a little higher up the bank on the north side of the dent in the outcrop shown on the map, but shows less than the sections on either side of it.

The third section is provided by the Hopwas Gravel Pit, which lies on the west side of the canal at the north end of the village. The pit consists of two excavations, the first of which shows superficial gravel only. A road enters the second excavation by a cutting through sandstones of the Hopwas group, and illustrates well their calcareous nature and proneness to decompose, as well as their rich red-brown colour. Here also the fragments occur in lines and small lenticles; limestone is rare, while subangular quartzite is common. On the left or south side of the entrance the calcareous breccia can be seen to come on above with an apparently high dip, but, farther in, the excavation fails to reach the base of the gravel, and the relationship of the breccia to the Bunter Pebble Beds, which form the lower part of the back of the quarry, is not disclosed. The appearance of a high dip referred to is due to a small landslip having taken place before the Glacial sands and gravels were deposited. It is in the reverse direction to the normal dip, which close to the Hopwas Fault is always south-eastwards towards the fault. The eastern cheek of the fault is formed of Keuper Marl, which has been deeply eroded. The rocks on the other side left unsupported laterally, and resting on Keele Marls, slid, and as they did so acquired the inward tilt usually observable in landslips.

A little south of Hopwas village a cross-fault throws the breccia and sandstone up to a sufficient height to allow some of the underlying Keele Beds to come to the surface. An escarpment is consequently developed which continues almost to the Watling Street, where it ranges westwards as far as a fault above Hints village. For much of the distance the breccia is cut into by the Bunter, but it is present in force in a plantation near Common Barn, where it was quarried for spreading on the land owing to the calcareous nature of the matrix and the great number of limestone-pebbles it contains. The Bunter makes merely a small rise on top of the main feature escarpment of Hopwas breccias and sandstones.

Hints Area.—On the north side of the Bourne Brook, to the west of Hints Hall, the Breccia if present must be thin. On the south side of the brook its mode of occurrence is well illustrated in some outliers. Most of them are more or less covered by Bunter, which partly and, in at least one case, wholly transgresses the breccia. In these outliers the pebbles and fragments consist of the usual types. Well-rounded pebbles derived from the Carboniferous Limestone are fairly common, and among them crinoidal rocks are the most abundant, but a few are fine-grained or compact, and rarely they are oolitic. The matrix when not loose sand is a highly calcareous sandstone. The other pebbles are much the same as at Hopwas, but there seem to be a few more igneous rocks, and one specimen was found of Spirorbis-limestone. Northwards of Weeford Park the breccia appears to be absent for half a mile, but it reappears at the northern corner of the park, and from this point southward and westward it is persistently present over a large area. In the park it forms a broad flat strewn over with angular or subangular and often pitted quartzite-fragments. In an old sandpit north-west of Stockfields the matrix of the sandstone is distinctly coarse.

South of the Canwell Gate fault the outcrop expands greatly, but exposures are rare. In the neighbourhood of Little Sutton, some 650 yards west of Marl Pit Hall Farm, a pit has been dug apparently in a marl-band intercalated in the series.

Close to the west edge of the Bunter outlier near the Lichfield road a fragment of fossiliferous Silurian rock was found in the breccia; its occurrence foreshadows the oncoming of these fragments farther south and west. During the construction of the Four Oaks sewers a series of cuttings, shafts and tunnels were made alongside the railway at Hill and Mere Green; all the shafts penetrated the breccia-beds, while the more southerly entered the underlying Keele Beds. The debris from a shaft about 250 yards north of the railway-bridge may be taken as typical of the breccia-beds; it consisted of loamy sand with masses of hard calcareous sandstone and breccia, and of many loose stones. The stones in the breccia were composed of quartzite (up to 12 in. long), limestone (up to 8 in. long), igneous, and other rocks. G. B.

Four Oaks and Sutton Coldfield.—To the north-west of the Hints Fault in the neighbourhood of Four Oaks the Bunter occurs in outliers only, and the breccias have a large outcrop, extending through the northern part of Sutton Park to Streetly, where the beds pass beneath the main mass of the Bunter Conglomerate, only re-appearing at Barr Beacon. The structure of this area was first recognised by Messrs. C. J. Gilbert[1] and J. Landon,[2] who considered that the Pebble Beds rested as a mere shell on the lower group and did not dip regularly to the east. Landon, however, underestimated the importance of their outcrop and much of what he considered to be Lower Mottled Sandstone belongs really to the upper part of the Pebble Beds, above the true conglomerate.

Over this area the Hopwas beds are plainly unconformable to the older rocks, for they rest on a much lower level in the Keele Beds at Barr Beacon than at Streetly, as proved by the Little Aston Boring (p. 62). On the other hand, they are linked with the Trias in not being involved in the movements that affected all rocks up to and including the Hamstead Beds at the end of Palæozoic time. But they were evidently subjected to erosion before the deposition of the Pebble Beds, as the junction of the two is often irregular and uneven. Their thickness consequently varies. Its maximum occurs at Hill and Mere Green, where it must reach 100 ft.; near Streetly, too, it must be considerable.

The breccia-bands consist of a coarse purplish-brown matrix of sandrock containing angular pieces of grey quartzite, sandstones, and igneous rocks. Here the limestone-pebbles, so conspicuous at Hopwas, dwindle in number and die out, their most westerly occurrence being at Mere Green, where they were encountered during the excavations for the Four Oaks sewer. By far the commonest fragments are those of quartzite, which occur in sharply-angular pieces, often reaching 5 to 6 in. in length. They resist weathering long after the rest of the rock, and litter the fields along the Breccia outcrops. Interbedded with the breccias are coarse reddish-brown calcareous sandstones, frequently with thin layers of angular fragments, and occasionally with marl-bands. During the construction of the sewer along Rosemary Hill Road, Streetly, one such marl-band was encountered in a man-hole 400 yards south-east of Streetly Lane. The following section is abridged from an account communicated by the contractors, Messrs. G. Law & Co.:—

		Ft.
Drift, gravel, sand and clay		12
Pebble-Beds; hard, tight gravel		11
Hopwas Breccia	Rock and rough gravel ...	17
	Marl...	1
	Gravel and sand	4½

The marl was red, very tough, and yielded *Estheria* cf. *minuta* (Alberti), the only fossil recorded from these beds. A feature of the breccias was the abundance of pieces of brown sandstone of Llandovery age, containing such fossils as *Orthis*

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[1] C. J. Gilbert, 'Geology of Sutton Coldfield,' A paper read before the Vesey Club, 1890. *Privately printed.*

[2] J. Landon, 'The Barr Beacon Beds,' *Proc. Birm. Phil. Soc.*, vol., vii (1890), pp. 113-126.

sp., '*Petraia*' *sp.*, and ? *Favosites*, while similar sandstone collected west of Hill Hook Mill contained *Pentamerus* ?. No pebbles of Carboniferous Limestone were found, and, as usual, the commonest type was the grey quartzite mentioned above.

North of this the junction with the Pebble-Beds was well seen in the Rosemary Hill Road section, south of Little Aston Lane. Working from the north, it was first encountered at a depth of 45 ft., 80 yards from the fork of the roads. Beyond this point it occupied the same level above the floor of the tunnel for a distance of 35 yards, when an upthrow fault caused the rest of the section to be entirely in the Breccias. In contrast to the Sutton section, the junction here is remarkably regular, and the only evidence for erosion consists in a few small funnel-shaped pipes of conglomerate penetrating the beds beneath. These pipes are rarely more than 1 ft. in depth, and the pebbles are of ordinary Bunter type, showing no special arrangement. As usual, the lowest Pebble-Beds contain a great number of pebbles derived from the breccias.

Near Sutton Coldfield the beds are best seen in the Park, in the quarries round Blackroot Pool and Keeper's Pool, where they have been described by Mr. C. J. Gilbert (*op. cit.*), who recognised their unconformity to the beds below and correlated them with the Permian. Landon (*op. cit.*) also mentions them in his account of the Barr Beacon beds, but takes them to be Lower Mottled Sandstone. In the Keeper's Pool Quarry the base of the Pebble-Beds was until recently well seen, and the upper surface of the Hopwas beds was deeply eroded. The series reaches its maximum thickness in the eastern part of the quarry, where a breccia-band 3 ft. thick passes up into a brown sandstone. Towards the west the conglomerate rapidly cuts out, first, sandstone, and then a part of the bed beneath, until the western wall is entirely in the newer formation.

The large quarry at Blackroot Pool provides an excellent section, and in the eastern part shows the following details:—

		Ft.
Drift, unbedded sands and gravels		5
Pebble-Beds	Gravel with thin lenticular bands of soft sand-rock	20
Hopwas Beds	Breccia with thin sandstone beds	2
	Fine-grained brown sandstone	1
	Breccia	2

Below the floor of the quarry, according to Mr. C. F. Marston, the Hopwas beds have been penetrated to a depth of 20 ft. without reaching their base. The junction with the Pebble-Beds is not so well seen here as was the case at Keeper's Pool Quarry, but again it appears to occupy a lower horizon in the western than in the eastern part of the quarry. At the junction there is a good deal of dark staining, which, besides coating the pebbles, penetrates the cracks in them. The constituents of the breccia are of varied nature, and include, in order of abundance, grey quartzite, igneous rocks, volcanic ashes, Silurian sandstones, Carboniferous cherts, red sand-rock of Keele Bed type, and fine-grained whitish quartzite. Of these, the first is the most important, and is similar to the Cambrian quartzites of the Midland district. In it bright-green grains of chlorite are usually present, and appear to be characteristic. The igneous rocks are always so decomposed that identification is impossible. The sandstones vary from dark olive-green or black to brown, and are frequently fossiliferous; they appear to be of Llandovery age.

The interbedded sand-rocks are impersistent and die out rapidly. They are soft, friable, and subject to great variation in coarseness of grain. In common with all the Upper Carboniferous and Triassic rocks, false-bedding is prominent. C. H. C.

Cannock Chase Area.—It is not possible, as a rule, to see what part of the Hopwas Breccia is here represented; but at Lodge Hill, at the south-west end of the outcrop of Bunter, there is one small lenticle of sandstone with small angular pellets and pebbles that may possibly represent the Breccia. It is too small to be shown even on a six-inch map.

The descriptions of the rocks passed through in shafts and borings, such as those of Wolseley Park, Brindley Bank, The Birches, Fair Oak, Sherbrook, Moor's Gorse, etc., as furnished by the sinkers, are rarely sufficiently precise to enable the possible representative of the Breccia to be identified; it would pass under the names of 'conglomerate' or 'pebbly sandstone' or even simply 'sandstone.'

Half a mile south-east of Moor's Gorse some beds of buff and red sandy gravel and sand-rock, exposed at a spring and in a road-cutting on the Marquis's Drive, differ from the ordinary Pebble-Beds in colour and composition and resemble beds that form the base of the Bunter farther south. W. G.

A section at the base of the Trias a few yards west of the Brick Kiln Shafts of the Brereton Colliery (a mile south-west of Brereton) shows 20 ft. of yellow gravel containing much debris of Coal Measure sandstone and shale. Similar rock is exposed at the end of an inclined plane 300 yards to the south-south-west, while red and buff sand-rock can be seen in the roads at Wandon. These beds are succeeded upwards by the ordinary quartzite-conglomerates, dug for road-stone at the Stile Cop gravel-pits a little to the north-west. About 300 yards south of Wandon some old clay-pits on the site of a brick and tile works show red marl, possibly stained Coal Measures, but more probably a band at the base of the Hopwas Beds; while half a mile to the south-west, at the head of the Pleachley valley, some sand-pits in the same basement-group display reddish-buff, coarse, false-bedded, pebbly sand-rock containing much subangular Coal-measure sandstone debris and rolled pieces of red marl. Still farther along the basal escarpment, the lowest beds at Hazelslade, and also in a large sand-pit at the north-eastern foot of the hill crowned with the circular reservoir, present similar characters; while in the sand-pits at Littleworth the beds, which are at least 40 ft. thick, are well exposed, and consist of false-bedded pebbly red and yellow coarse sand-rock. Rolled lumps of red marl, up to 2 ft. in length, caught up in the rock, were probably derived from the underlying Etruria Marls.

Two minute outliers of what must be regarded as Triassic basement-beds have been detected on the Coal Measures near Cannock Wood, between Brereton and Chasetown. The larger one (shown on the map) is 350 yards long, and forms a bold ridge bounded along its eastern side by Keuper Marl brought against it by the eastern boundary-fault. At its northern end the beds are well-displayed in the roadside, 150 yards south of the Methodist Chapel at Cannock Wood, where they form a bold bluff and are dug for sand. The buff, soft, pebbly sand-rock passes down into a basement-bed, several feet thick, of angular quartz-pebbles, which rests on 2 or 3 ft. of red, yellow, and grey Coal-measure shales and clays immediately overlying a 15-in. coal. The Triassic affinities of the sand-rock first attracted the attention of the late Mr. G. M. Cockin.

The second and smaller outlier, 100 yards long by 50 wide, is exposed in a quarry at Shargrass Castle, a cottage half a mile farther to the south-west, where the rock is a firmly-cemented massive coarse conglomerate of quartz- and quartzite-pebbles, with partings of brick-red fine-grained sandstone. The cement is largely ferruginous, and some of the pebbles are of red jasper. The rock appears to occupy a hollow or pocket in the surface of the Coal Measures by which it is completely surrounded.

On the eastern side of the coalfield, between Brownhills and Shire Oak, though the Bunter margin is presumably not faulted against the Coal Measures, the lowest beds are nowhere exposed. South of Shire Oak the junction is faulted as far as Pool Green, near Aldridge; but beyond this point the basement-beds emerge and can be followed southward.

A small sand-pit 60 yards south of Green Lane Cottages (midway between Pool Green and Barr Common) showed in 1911 about 4½ ft. of coarse Bunter shingle overlying red and yellowish-brown sand-rock, loamy and marly, with some quartzite-pebbles at the bottom, exposed to a depth of 8 ft. Though not quite typical, this sand-rock may be the top of the Hopwas Beds, and the overlying shingle the lowest of the ordinary Pebble-Beds, which come on above and are well-exposed on Barr Common. South of the last-named place the shingle-beds make a bold scarp; but the beds that lead up to it are not exposed till we reach the Walsall-Sutton road north of Beacon Farm, where a sand-pit at the cross-roads shows 10 ft. of pale-red and yellow sand-rock, with lines of small subangular pebbles and partings of red marl. The pebbles consist mainly of quartzite; but there are others of sandstone (? Coal Measures), red and white crinoidal chert from the Carboniferous Limestone, granitic and andesitic rocks, and desilicified rhyolites.

An old quarry (now occupied by a bungalow) below the north-western corner of the reservoir near Barr Beacon shows 12 ft. of similar sand-rock. Shortly beyond this the outcrop passes into Sheet 168. T. C. C.

CHAPTER VII.

TRIASSIC ROCKS.

GENERAL ACCOUNT.

By G. BARROW.

Triassic Rocks cover more than half of the area here described. The lower subdivisions show great variations in thickness, but the Keuper Marl is more uniform and appears to have been thickly deposited over the whole area.

The Lower Mottled Sandstone has been nowhere recognised, and the Upper Mottled is generally absent. Nor are sandy bands developed in the Keuper Marl, for the Arden Sandstone of Warwickshire does not extend into this area, and the Upper Keuper Sandstone of the ground to the east (Sheet 155) is either absent or represented only by sandy marl in the north-eastern part of the district.

At the base of the Keuper Marl fine-grained evenly-bedded sandstones alternate with marl. The sandstones become somewhat coarser and false-bedded downwards, and this part may represent the Lower Keuper Sandstone, while the finer beds would be equivalent to the Waterstones. But the two are not separable, and can only be grouped together under the name of Keuper Sandstone. The building stones which are developed in Staffordshire, Shropshire and Worcestershire between the marl and the sandstone are poorly represented. The area occupied by beds of the Waterstone type is small, except possibly in the north-eastern part of the map, near ground in Sheet 155, where the finer beds are better developed. The great thickness of sandstone recorded in the Fradley Shaft (p. 276) and in the Lullington boring (p. 155) is probably due to thickening of the Waterstones.

The beds present may therefore be tabulated as follows in descending order: —

Keuper	Keuper Marl. Keuper Sandstone, including the Waterstones.
Bunter	Upper Mottled Sandstone. Pebble-Beds.

BUNTER SANDSTONE AND PEBBLE BEDS.

The Bunter is of the normal Midland type and consists of beds of red-brown sandstone, generally white-speckled and micaceous, and with yellow or grey bands. The grain is more or less coarse, and scattered pebbles are common. Associated with the sandstones are a number of shingle-beds (Pebble-Beds) generally occurring as wedges of varying length. The pebbles are mostly well rounded and vary much in size; the larger ones tend to occur in the basal band, and in these the rounding is not so complete. The matrix is generally a coarse sand, but in some cases the pebbles are massed together without any interstitial material. Occasionally it is calcareous but it is not of a character to offer serious obstruction to underground flow of water, even at great depths, in this respect differing from the Keuper Sandstone. The Pebble Beds consequently form a most valuable source of water supply.

The proportion of pebble-beds to sandstones varies locally, but as a whole the pebbles are smaller towards Birmingham and the proportion of sandstone increased.

The majority of the pebbles are composed of quartzite varying in texture, in the amount of felspar present and in colour; one of the most interesting is a liver-coloured rock of an origin which remained long unknown. The rock which comes next in abundance is vein-quartz; other pebbles, present in smaller numbers, include quartz-felspar grit, purple sandstone, jasper, lydite, Carboniferous and other limestones, Carboniferous Limestone chert, and Silurian sandstone with fossils. There is a fair sprinkling of igneous rocks, mostly felsite, though a few are of granite, but all are too rotten for determination. The abundance of pebbles, often of considerable size, composed of quartz-schorl, is a feature of this area.

The origin of the pebbles has been much discussed. The view that they were derived from a northerly (Scottish) source was long maintained, but has received little support from recent investigations. The subject is too wide to be dealt with in the description of a limited area, but it may be pointed out that the assemblage of rocks in the Bunter pebbles of the district under description differs from the Highland conglomerate in the comparative scarceness of igneous rocks, and that so far from becoming more abundant and larger towards the north, the pebbles become scarcer and smaller and eventually disappear in the northern counties.

On the other hand the quartz-schorl rock, and the fragments of altered killas that occasionally adhere to it, can be matched in Devon and Cornwall. It has been even suggested[1] that a local source may be looked for, and that this may be true for some of the pebbles has recently received confirmation, for a liver-coloured quartzite has been penetrated in the Jubilee pits of the Sandwell Park Colliery. It must be remembered, however, that the older rocks were for the most part buried under Carboniferous strata when the Bunter was being distributed.

The quartzites of the neighbourhood of Birmingham are cut up by a natural cross-jointing into small quadrangular fragments, which are approximately of the same proportions as the Bunter pebbles. When such fragments undergo the process of rounding they are subjected to grinding and hammering, presumably by wave-action, and it is interesting to note that Bunter pebbles show nodes of percussion attributable to such hammering no less clearly than do the flint-pebbles of the Lower Tertiary strata.

A well-known feature of the pebbles is the pitting of the surface, which has resulted from the pressure of one pebble against another. The pebble-beds no doubt shrank as they dried, but there would be less shrinkage in beds composed chiefly of pebbles. The compression thus caused, combined with that due to the weight of superincumbent strata, jammed the pebbles together with sufficient force to develop hollows where they touched. In undisturbed Bunter the pitted pebbles are still in contact, but in drift gravels, the pitted pebbles, though abundant, are never in their original positions.

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[1] W. J. Harrison, *Proc. Birmingham Phil. Soc.*, vol. iii, 1881-2, p. 157.

The area occupied by the Pebble-Beds is characterised by combe-like hollows, and where these are planted they form distinctly beautiful scenery. The famous Cannock Chase in the north-west of the district and the less known, though extremely picturesque Hopwas Woods, some two miles west of Tamworth, are good examples of Pebble-Bed scenery. The soil is usually poor and hungry, but that of the associated sandstones, though light, is distinctly better.

The occurrence of ores of copper and lead in the Bunter of Cannock Chase, both at the Shoal Hill pits and in the Fair Oak Colliery shaft, was made known in 1873 by W. Molyneux.[1] Soon afterwards he found them in the Huntington gravel-pits, where they have been noted also by A. Timmins.[2] The amount of copper-ore in one case was sufficient to fit the screened-off sand for use as a weed-killer. So far as is known these ores have not been met with in the more southern part of the area under description, but they have been noted much farther north.

The large outcrop in the south-central part of the district is repeatedly interrupted by faults that bring Hamstead Beds to the surface or throw down Keuper. Southwards this outcrop terminates in a series of outliers, most of which rest on Hopwas Breccia. In the south-eastern part of the district the Keuper Sandstone rests directly on the Coal Measures. Whether the absence of the Bunter is due to its having been denuded away before the Keuper was deposited or to its never having been deposited here is a matter for discussion.

That the thickness of the Bunter varies considerably has been proved by various sinkings, as well as by observations at the surface. Local variations are caused by the unevenness of the floor on which the Bunter rests; but there is evidence of a general thinning in a south-easterly direction, towards the region near and south of Tamworth, where the Bunter disappears entirely. It is not certain to what extent this disappearance is due to the original margin of deposition having been passed, or how far it may be attributed to erosion anterior to the deposition of the Keuper Sandstone. Probably both explanations have a measure of truth, for erosion between the Bunter and the Keuper is evidenced in several distinct areas. Thus in the area immediately to the east, in Sheet 155 of the one-inch map, reason was found to believe that the Keuper lies unconformably in hollows of the Pebble-Beds, and abuts against ridges formed by them.[3]

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[1] *Rep. Brit. Assoc.*, for 1872 (1873), pp. 116-117; and *Geol. Mag.*, 1873, p. 16.

[2] *Proc. Liverpool Geol. Soc.*, vol. v (1884-1888), pp. 256, 257.

[3] 'Geology of the Country between Atherstone and Charnwood Forest,' *Mem. Geol. Surv.*, 1900, p. 33. *See also* the *Geological Map*, Sheet 155, New Series, especially the district on the south-west of the Leicester Coalfield.

In the Cannock Chase area the full thickness of the Bunter is nowhere seen, but it may be present towards the north-eastern part, at the Brindley Bank boring, situated about a mile north of Rugeley (Sheet 140). From the borer's account (p. 271) it appears that there may be some 30 ft. of either Upper Mottled Sandstone or Keuper Sandstone present, and if so the full thickness of the Bunter Sandstone and Pebble-Beds here is roughly 460 ft. Within the Cannock Chase area, at Littleton Colliery (p. 134), a thickness of 360 ft. was proved, but the upper part is here absent.

Eastwards of Cannock Chase a boring at Maple Brook, 3 miles west of Lichfield, after penetrating about 100 ft. of Upper Mottled Sandstone, passed through 325 ft. of sandstone, with lines of pebbles in the lower part. The Pebble-Beds were penetrated to a depth of only 18 ft., but as they are over 100 ft. thick in the neighbourhood the Bunter here must be over 425 ft. in thickness. Two and a half miles south-east of Maple Brook a well and boring at Pipe Hill proved a thickness of at least 274 ft., or possibly more, for it is not easy to say where the underlying Keele Beds begin (p. 277), but in any case the total has considerably diminished. The overlying loamy sandstones, apparently representing the Upper Mottled Sandstone, are much thinner than at Maple Brook, but their presence shows that the decrease is not wholly, if at all, due to erosion at the base of the Keuper.

Some 3 miles farther to the south-east is a well and boring at Shenstone, where the Upper Mottled Sandstone has disappeared at the surface, and the base of the Bunter was reached at 170 ft., or possibly rather less. The well starts only a little below the top of the Bunter, the full thickness of which can therefore hardly reach 200 ft.

Beyond this we have to rely on surface evidence. Farther to the south-east, about Hints, the thickness can scarcely reach 150 ft., and about Hopwas it is probably about 100 ft. South of this the Bunter disappears, as already mentioned. Eastward of the coalfield (in Sheet 155) it has been proved in a boring made since the map and memoir were published. The record is given on p. 282. G. B.

Cannock Chase, etc.—The junction of the Bunter formation with the Coal Measures is never seen at the surface, but on both sides of the Hednesford Valley its position is well defined. At Cannock town the outcrop is completely hidden under Drift, but it emerges from beneath it in Lodge Hill south of Wyrley Brook, and is thence clearly traceable southwards to the Moat, S.W. of Cheslyn Hay, where it treads S.W. and so passes out of the area. At Littleworth, in the Hednesford area, the Bunter reposes on the lower beds of the Etruria Marls, 1,000 ft. above the Deep Coal, and at Fair Oak Colliery on measures below this seam, but once more on Etruria Marls at Cheslyn Hay. Moreover, the folding and extensive faulting of the Coal Measures is feebly, if at all, represented in the Bunter. Further, the removal of at least 1,000 ft. of Middle Coal Measures at Fair Oak Colliery by no means represents the total amount of strata denuded, for there is no doubt that the Etruria Marls, Halesowen Sandstone, and Keele Beds were at one time present, and that some 3,000 ft. of Upper Carboniferous strata were eroded before the Trias was deposited.

That this eroded surface of the Carboniferous was uneven is certain, but data are as yet wanting from which its configuration can be determined. On the whole it sloped gently down to the west on the western flanks of Cannock Chase, and rapidly down to the north between Brindley Bank and Fair Oak Colliery. Local and striking irregularities in the surface of the buried Coal Measures are not wanting, as at the Littleton Collieries and at Fair Oak Colliery.

The thickness of the Bunter is not known; it is certainly greater than 360 ft., as this amount was proved in No. 1 and No. 2 shafts of the Littleton Colliery. Owing to the irregular deposition of the formation the amount and direction of dip cannot be satisfactorily determined. On the whole the formation faintly outlines the anticlinal structure of the Coal Measures, but the dip does not exceed 5°, and whatever faulting occurs is certainly of much less intensity than that found in the Coal Measures.

Exposures are not common, and seldom extend for more than 10 to 20 ft. in depth. The record of the Pool Pits of the Cannock and Rugeley Colliery, however, gives the character of a part of the Bunter.

Bunter, at the Pool Pits.

	Thickness.	
	Ft.	In.
Gravel (loamy)	16	0
Soft sand and gravel	30	0
Fine gravel and sand	20	6
Soft sand-rock	15	0
Wet sand and gravel	15	0
Quicksand	9	0
Red marl	2	6
Wet sand and gravel with patches of marl ...	12	6
Soft sand-rock, heavily watered	16	0
Wet sand and gravel	3	0
Soft sand-rock	9	6
Light soft sand-rock	6	0
Strong mingled rock	4	6
Light soft sand-rock	5	0
Light fine gravel	5	0
Light sand-rock, hard	19	0
Coal Measures	—	
	188	6

This section, in which the lower part is made up chiefly of sand-rock and the upper part mainly of loose conglomerate, applies to the Chase generally. South of the Pool Pits, for instance, the basal beds seen in a large quarry at Littleworth consist of buff pebbly sandstone; of soft red sand-rock in a sand-pit by the side of the Stafford Road, near Oldfallow Farm, south of Huntington; and of red and buff sandstone, containing thin lenticles of pebbly sandstone, in a quarry at the foot of Lodge Hill, north-west of Cheslyn Hay.

The bands of loose conglomerate in the higher beds are not persistent, but occur as lenticles, varying greatly in thickness and lateral extension. Thus, at the entrance to the railway-cutting near Brindley Valley, north of Hednesford, a bed of unconsolidated conglomerates, over 40 ft. thick, wedges out to 6 ft. thick in the eastern part of the cutting.

Pebbles are abundant over the Chase, and are not infrequently massed together in lines along the sides of the combe-like valleys, so characteristic of the district. Such banks are not to be taken as representing the outcrops of conglomerates but are to be considered as accumulations of pebbles, mixed with sand, which is usually bleached white, washed down the slopes from higher levels and coming to rest wherever the configuration of the ground has permitted.

On the western flanks of the Chase, at the entrance to Dark Slade Wood, and around the Reservoir in Gravelly Bank Wood, shallow quarries show brick-red and buff sandstones with lenticles of conglomerate. In the latter the pebbles are chiefly quartzites, but some are composed of fossiliferous Silurian grits, notably those in the quarry in Dark Slade Wood. South of the Reservoir exceptionally good sections occur around Huntington, one quarry, west of the Pumping Station, giving an exposure 100 yards long and 40 ft. deep. The order of the beds varies slightly, but the following descending sequence at the northern end of the excavation is departed from only in detail:—Loose conglomerate, 12 ft.; pebbly sandstone, 2 ft.; consolidated conglomerate, 20 ft.; grey sand-rock, 2 ft.; consolidated conglomerate, 8 ft. The beds dip west at 4°. Among the pebbles, those of white and liver-coloured quartzites predominate, but there are a few examples of encrinital cherts, ashy rocks, and hardened sandstones, most of the pebbles being shattered and the pittings pronounced. In the consolidated conglomerates copper carbonate occurs sparingly as a cement, with grains of galena disseminated through the matrix. According to Molyneux,[1] the gravel bands were formerly in much request as affording a material for garden paths and private roads, owing to the copper salts proving inimical to the growth of weeds.

To the north, sand-rock with lenticles of conglomerate dipping west at 5°, is cut through in the mineral line of the Littleton Collieries. Close by, in No. 3 Shaft, the Coal Measures were found under 234 ft. of Bunter, but in No. 2 Shaft, 500 ft. to the north-east, the Bunter was found to be 360 ft. thick, the height of the shafts above O.D. being the same.

Over Shoal Hill the Bunter conglomerate is at the surface, and in the shallow quarries near Arnott's Grave consists of coarse red and yellow pebbly sandstone; but to the south, over Cannock town, up to Wyrley Brook, all the solid formations are hidden under Drift, and there is no information obtainable until they emerge in Lodge Hill (p. 128). W. G.

Near Brereton conglomerate is dug for roadstone at a large quarry[2] just outside the northern end of Chetwynd's Coppice; the material is yellowish-grey and contains seams of pebbly yellow sandstone. The beds are cut by a fault of small southerly downthrow, given off, doubtless, by the adjacent eastern boundary-fault.

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[1] *Geol. Mag.*, 1873, p. 18.

[2] Photograph No. 1518 in the Survey Collection.

Farther south, at Stile Cop, conglomerate is dug for roadstone in two pits at the roadside east of Regent's Wood. In the northern one,[1] at the foot of Stile Cop, some of the quartzite-pebbles reach 6 in. in length, though the average length is 2 or 3 in. In the southern pit, 300 yards north of Wandon, several small tabular fragments of highly-fossiliferous Upper Llandovery sandstone yielded the following[2]:—

'Favosites' sp.
'Petraia' sp.
Crinoidal columnals
Atrypa reticularis (*Linn.*)
Camarotoechia nucula (*J. de C. Sow.*)
Orthis (Dalmanella) elegantula *Dalm.*
Stricklandinia lens ? (*J. de C. Sow.*)
Tentaculites anglicus *Salt.*

At Moor's Gorse, 2 miles north-east of Hednesford, a large roadstone pit shows the usual conglomerate-beds with seams of pebbly sand. Some of the pebbles here also are fossiliferous; one[3] yielded *'Petraia' sp.* and *Atrypa reticularis* (Linn.). The L. & N. W. Railway, half-a-mile to the south-west (at the site of Baland's Pool), exposes a fine section[4] of conglomerate with impersistent beds and partings of pebbly red sandstone.

The shafts of the Fair Oak Colliery (p. 75), still farther to the north-west, proved 286 ft. of Bunter sandstones and conglomerates in which, as stated on p. 132, traces of galena and copper pyrites were found.

South of Brereton the Pebble-Beds emerge from beneath the Lower Keuper Sandstone about Upper Longdon, where most of the exposures show pebbly, coarse, red sandstone, the pebbles having the size of peas and walnuts. In Beaudesert Park the conglomerate exposed in some crags between 400 and 500 yards north-west of the Hall contains a large proportion of calcium carbonate in its sandy matrix, and is firmly coherent.

The Pebble-Beds rise westward from beneath the Upper Mottled Sandstone at Brownhills, extend southward past Aldridge, and leave the map at Barr Beacon. About Brownhills the ground is of low elevation, and the outcrop is covered by Glacial drift; but a good section is afforded by a long railway-cutting between Brownhills station (L. & N. W.) and New Town, in which dull-red, false-bedded sand-rock, of medium grain, with some bands of red marl, is exposed to a thickness of 30 or 40 ft. Rolled lumps of red marl, derived doubtless from the contemporaneous erosion of the marl-bands, are numerous; but with this exception pebbles of any kind are rare or absent. Small hard nodules of the size of marbles and of a black colour are of frequent occurrence. On analysis by Mr. E. G. Radley, these proved to be local concentrations of manganese oxide, with traces of nickel. Similar nodules, and also thin bands of the same character, have been observed in a sand-pit at Ogley Hay, and at Shire Oak. The rock in the railway cutting is traversed by lines of bleaching, along which the red colour has changed to pale yellow. The beds dip E.N.E. at 5°, and at the 12th mile-post are cut by two disturbances ranging nearly north-and-south, one being a westward downthrow of 6 ft., the other a small westward downfold (p. 170).

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[1] Photograph No. 1544 in the Survey Collection.

[2] T. C. C. 2102-2108.

[3] T. C. C. 2110.

[4] Photograph No. 1542 in the Survey Collection.

North of the Watling Street, on the same line of strike, a sand-pit adjacent to the canal (at the end of a street called The Fault) shows 15 ft. of coarse, dull-red sand-rock with pebbles of red marl, quartz, and of other rocks, which in some instances have had the effect of bleaching the surrounding sand. The pebbles having this effect are of felspathic grit and fine-grained sandstone, which may have contained pyrite, by the decomposition of which the red oxide may have been reduced to a pale yellow oxide or converted into a salt subsequently removed in solution. Red marl pebbles (up to 4 in.), and small pebbles of quartz and quartzite, either scattered or in nests, are present in the sand-rock exposed in a cutting on the mineral railway a little farther north.

In somewhat higher beds a sand-pit on the south side of the canal, 200 yards north-west of Ogley Hay Chemical Works,[1] contains two thin bands of red marl that have yielded *Estheria* cf. *minuta* (Alberti), a fossil not hitherto recorded from the British Bunter. The pit shows about 22 ft. of dull-red medium-grained false-bedded sand-rock, with lines of yellow bleaching. The marl-bands that yielded the fossil are near the bottom of the pit; they are about 1 ft. 8 in. apart, range up to 9 in. thick, and break down in places into detached marl-pebbles, scattered in the sand-rock. A narrow film of the sand-rock in contact with the marl-bands is charged with black oxide of manganese.

Farther south, at Shire Oak, the outcrop of the Pebble-Beds forms higher ground, and shingle-beds appear in force. The lowest visible beds of the subdivision are those exposed, in 1911, 350 yards south-west of the Shire Oak Inn, in a sand-pit, which shows 10 ft. of red loamy sand-rock, with scattered pebbles, overlying pebbly coarse sand-rock, visible to a depth of one foot. Irregular lines and thin seams of manganese oxide are present. The beds in this pit cannot be referred to the Hopwas Beds, which, if present along this part of the outcrop, are nowhere exposed. Good sections of the conglomerate-bands are afforded by some gravel-pits beside the Lichfield road, 200 yards north-east of the Shire Oak Inn, where a 12-ft. bed of shingle overlies sand-rock in which there are sandstone and quartzite pebbles, scattered and in lines, some of which have bleached the surrounding red sand.

South of Upper Stonnall, as far as Pool Green, near Aldridge, the western margin of the Pebble-Beds is faulted, forms no escarpment, and affords no evidence that the Hopwas Beds are present. At Aldridge a sand-pit on the western side of the New Road, 100 yards S.S.E. of Lea House, shows 3 ft. of sandy gravel drift over 8 ft. of sand-rock, containing red marl pebbles up to 2 in. in length, and a few of quartzite. These beds, although close to the limiting fault, do not resemble the Hopwas Beds. The Midland Railway, under the bridge 600 yards east of Aldridge Station, shows nothing but red sand-rock containing scattered pebbles. The fault above referred to presumably crosses the railway a few yards east of the road-bridge at the station; but as the cutting is grassed it is impossible to say whether the Hopwas Beds are present. They come in, however, a little farther south (p. 129), and are overlain by shingle-beds of the usual type, which give rise to a low escarpment at Barr Common. Here the shingle-beds are well exposed in several gravel-pits, in which the pebbles range up to 6 in.; among them some of crinoidal white chert from the Carboniferous Limestone are noticeable.

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[1] Six-inch map, Staff. 57 N.E., locality Eλ1. Reg. Nos. of specimens, T. C. C. 2045-2051. See *Rep. Brit. Assoc.* for 1913, p. 475 (1914).

From Barr Common to Barr Beacon the escarpment forms a strongly-marked narrow ridge; shingle-beds form the upper part, as is shown by the stony soil, while the Hopwas Beds form the lower slope. At Beacon Trees Farm (a little south-west of the reservoir) a section in the yard shows a 12-ft. bank of shingle, in which the pebbles range up to 9 inches in length. T. C. C.

In the northern part of the outcrop, east of Shire Oak, Aldridge, and Barr Beacon, the Pebble-Beds have a steady easterly dip the result of further movements along the pre-Triassic downfold, which is of such importance in the Carboniferous beneath. In the south-east, however, round Hardwick and Streetly, the direction of dip changes, and the beds are folded into a broad, gentle syncline, so that the Hopwas Breccias emerge at Barr Beacon and Streetly. At Shenstone they occur as an inlier, faulted on all sides except on the north, where they pass beneath the Keuper Sandstone.

Nowhere in this area do they exceed 250 ft. in thickness. They have been penetrated by borings at Shenstone (see p. 277), Little Aston, and at Bourne Vale (p. 278), giving respectively thicknesses of 163 ft. 6 in., 73 ft. 6 in., and 68 ft. 6 in. In the case of the Little Aston boring, however, the lower 20 to 30 ft. penetrated may belong to the breccia-series below. At Shenstone nearly the full thickness must have been proved, for the Keuper Sandstone outcrops close by.

The lowest parts consist of coarse conglomerates bedded with red sandrock, and passing up into a pebbly sandstone, which in turn loses its pebbles and becomes finer-grained until the soft Upper Mottled type is finally reached. There is also a great lateral variation in coarseness, and in the south-western part of the district the conglomeratic bands are thinner and the pebbles smaller than in the eastern part, a diminution which becomes pronounced in the ground south of Barr Beacon. It is in the Sutton district, therefore, that the conglomerates are coarsest. Here the lowest beds are exposed in the Park in Blackroot Pool Quarry,[1] where they rest on the Hopwas Breccia series. In them the largest pebbles sometimes reach 18 in. in length, in which case the rounding has not been sufficient to obliterate the original brick-like shape. In addition to the fine-grained quartzite, which forms the bulk of the pebbles, igneous rocks and white, friable Carboniferous cherts are abundant. The presence of pieces of brown sandstone, similar in type to that found in situ in the Breccia beds below, suggests that the breccias were eroded previously to the deposition of the Pebble-Beds. Mr. T. H. Waller[1] has described many of the pebbles and finds that the white quartzites frequently contain tourmaline. He notes their similarity to the schorlaceous elvans of Cornwall. Interbedded with the conglomerate are bands of soft red sand-rock, irregular in distribution and rapidly wedging in and out laterally. The actual junction with the Breccias is described on p. 127.

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[1] A little south of the ground between the two railways on the southern edge of the map.

During the construction of the Streetly sewer the lowest beds were well exposed in the man-holes in Little Aston Lane and Rosemary Hill Road. They were coarse and contained many pebbles apparently derived from the Breccia series (p. 127). In Newlodge Wood they are to be seen for 13 ft., under 5 ft. of drift, in a gravel-pit 300 yards south of St. Peter's Church. About 3½ miles north of Streetly the junction with the Upper Mottled Sandstone can be examined near Stonnall in a small pit in the garden of a cottage adjoining Thornes Church. It shows fine-grained, soft red sand-rock, overlying a rather coarser rock containing white clay-specks, a feature characteristic of the Pebble-Bed sandstones. No pebbles were found, but hardened marl-pellets are abundant along certain layers. About 12 ft. of these highest bands are exposed. C. H. C.

The Maple Brook boring, of which a section is given on p. 274, was situated nearly 4 miles W.N.W. of Lichfield. It reached the Bunter at a depth of 200 ft. The cores of that rock, when first brought out, were of a bright-red or pink colour, rather coarse in texture, with grains generally rounded. Calcareous cement was not prevalent, and the rock was highly permeable. The marl-bands were sandy, and of a red or green-mottled colour. The first pebble-bed was met at a depth of 225 ft. below the base of the Upper Mottled Sandstone.

South of the Canwell Gate fault there are three outliers of the Bunter resting on the Hopwas Breccia. In the northernmost, which forms the high ground north of Hill, there are pits for road-metal; the pebbles are often large. In a trial-pit the junction with the underlying Breccia was exposed, and seemed to be quite sharp, though uneven.

Near Weeford, about three-quarters of a mile south of Bourne Brook, and on the east side to the road to Coleshill, there are two pits each about 25 ft. deep, the more northern of which shows well the difficulty of distinguishing drift upon an outcrop of Pebble-Beds. The lower 15 ft. are formed of rock in situ, but in the upper part, though it is composed of the same material, many of the pebbles are vertical, many are broken, and the pitting of pebbles in contact does not correspond. There has been some rearrangement, but how much it is impossible to determine. The pebbles are of all sizes, some, which are not completely rounded, being as much as a foot in length. In the second pit there are some 10 ft. of incoherent, marly, micaceous sand with small pebbles, which is occasionally dug for mortar.

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[1] 'The Petrology of our Local Pebbles,' *Mid. Nat*, vol. xii (1889), p. 174-178; 214-219.

Between Weeford and Hints, on the north side of Bourne Brook, another pit 25 ft. deep (south of Buck's Head Farm) shows the shingle-beds associated with a few sandstones. Several small displacements are seen, but whether they are faults or due to slipping down the bank is doubtful. Another and smaller pit at Weeford, some 12 ft. deep, shows shingle-beds only on the western side and sandstone only on the eastern. The change may be due to wedging, but is probably caused by a fault which, farther west, displaces the outcrop of the Bunter. In this neighbourhood the beds dip northwards at a higher angle than usual; in the sides of the Lichfield road just above the brook the angle is as much as 8°. In an old pit at Thickbroom Farm a curving crack traverses the Pebble-Beds and sandstone to a depth of 8 ft. Slanting gently at first it steepens downwards to make an angle of 70° with the beddings. Its greatest width is 6 in., and it is filled with sand and pebbles. This crack is clearly not a fault, and is suggestive of contemporaneous rather than recent formation.

On the north side of the Bourne Brook, about 150 yards N.W. of Hints Hall, an old pit some 20 ft. deep has been turned into a garden. It shows well the simulation by the incoherent Pebble-Beds of recently-formed sand and gravel; the material is so loose here that the sides of the pit are largely held up by wattling. Though the pit is near a considerable fault, the beds are almost horizontal.

On the south side of the brook the Bunter forms a number of small outliers, showing an instructive contrast between the Hopwas Breccias upon which they rest and the Bunter conglomerate. The majority of the outliers have natural boundaries and occur on the crest of a ridge, but two of them are bounded on one side by the Hints fault and dip steeply towards it.

The Pebble-Beds and associated sandstones are well seen on the rising ground between Hints and Tamhorn, the best sections being in the neighbourhood of Hopwas. They have been quarried for road-metal along both sides of the Lichfield road a little above the water-works, and one of the pits (in operation in 1911) on the south side has laid bare a bed of sandstone showing the wedge-like form in which it occurs. A point of interest is the occurrence of some drift here, consisting of the typical pebbles set, often vertically, in clay and sand. At first sight it appears to be part of the Pebble-Beds, but at the left or south-east side it rests sharply on a bed of sandstone and the distinction becomes clear.

In a field next the bye-lane, about 300 yards above the water-works, there is a large quarry showing well both the sandstones and pebble-beds in characteristic lenticular form. The pebbles are sifted out and gathered in large heaps.

The basal beds of the Bunter are well shown in the gravel-pit to the north of the village and close to the canal, already described. The sandstones are yellowish, and contain some pebbles, but in the lowest bed the pebbles are of unusual size. Some of them are 9 in. long and resemble bricks with well-rounded angles, but though not completely rounded their surfaces are perfectly smoothed. Carboniferous chert is fairly common, but limestone is absent. In the Breccia Beds, close by, pebbles of limestone are abundant (p. 125).

The Whittington Barracks stand on an inlier of the Pebble-Beds which have been quarried in the western part, and the pits, though overgrown, serve to show the difficulty in distinguishing between incoherent Pebble-Beds and Drift. There are still two good quarries near Swinfen Hall, two miles south-east of Lichfield, which have been described by J. Landon.[1] In the southern pit good examples occur of the massing of small pebbles without the intervention of any interstitial matter. Small 'step-faults' are also well seen here.

A small inlier, on the west side of the road and railway about a mile and a half south of Lichfield, is bounded by faults on the east and south,[2] the eastern fault just crossing the north-east corner of the quarry. On the western side the basal beds of the Keuper Sandstone are seen resting on a Pebble-Bed, proving the absence of the Upper Mottled Sandstone. In one part of the quarry 20 ft. of the Pebble-Beds are seen and the matrix is cemented in places by crystalline calcite. From this quarry A. Aikin[2] has described a variety of pebbles. A collection of agates, made by Mr. Spencer G. Perceval, is preserved in the Museum of Practical Geology.

UPPER MOTTLED SANDSTONE.

The Upper Mottled Sandstone is present at the surface over a comparatively small and irregularly-shaped area lying about Chasetown, Wall, and Little Aston. The sandstones are fine-grained and soft, easily decomposing to an almost loose, loamy sand that is valuable as a moulding-sand. Even when met with underground the rock is still soft and in the two instances where it has been penetrated in borings it has failed to yield a core. The ease with which it yields to erosion has led to the formation of a large alluvial flat to the south of Wall, the boundaries of which more or less accurately define the outcrop.

The Upper Mottled Sandstone, like the Bunter conglomerate, thins away in a south-easterly direction, but does so sooner; similarly, it expands to the north-west, for it was 100 ft. thick in the Maple Brook boring (p. 275). How much farther this thickening continues there is no evidence to show. G. B.

On the eastern side of the South Staffordshire coalfield, between Brownhills and Hammerwich, some soft bright-red moulding-sand, intervening between the Pebble-Beds and the Lower Keuper Sandstone, may be classed as Upper Mottled Sandstone.

At Chasetown, at the northern end of the outcrop, the base of the Keuper makes little feature and is difficult to locate; but the soft and fine-grained bright-red sand proved in the graveyard of

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[1] *Proc. Birmingham Nat. Hist. and Phil. Soc.*, ser. 12, vol. i, 1895, p. 153.

[2] A. Aikin. *Trans. Geol. Soc.*, ser. 1, vol. iv, 1817, p. 426.

St. Ann's church is no doubt referable to the Upper Mottled Sandstone. Between the Institute and the gas-works, bricks are said to have been made from a marl-band that appears to intervene between the Bunter and the Keuper. That such bands are present in the Upper Mottled is shown by a section, east of New Town, in the angle between Watling Street and the road to the Triangle, where in a small sand-pit 2 to 8 ft. of drift gravel overlies 4 ft. of dark-red loamy sand-rock with a marly bed 2 ft. thick.

South of New Town, and a little east of the Ogley Hay chemical works, some extensive moulding-sand pits show about 22 ft. of red sand-rock, with some coarser and duller-coloured beds that resemble the sand-rock of the Pebble-Beds. The dip of 5° seems scarcely sufficient to carry the adjacent Pebble-Beds below the bottom of the pits, and it would appear that there must be a lateral passage of the one subdivision into the other—a view supported by some alternation of the two lithological types noticeable in the sections. T. C. C.

Characteristic soft sandstone can be seen *in situ* in the railway-cutting south-west of Wall, in a sunk lane a little north of the trigonometrical mark 491, about a mile east of Brownhills, and again close to the canal where it is crossed by the Lichfield-Walsall road. E. E. L. D.

The Upper Mottled Sandstone forms a tract of ground south of Sandhills and Lynn, for the most part flat and low-lying, except where protected from erosion by drift, as is the case east of Thornes. In it sections are rare, but at Bosses a sand-pit 6 ft. deep shows a fine-grained, bright-red sand-rock with streaks and patches of yellower material and entirely devoid of pebbles. This is the most easterly occurrence in this district of Upper Mottled Sandstone. At Shenstone the Keuper Sandstone rests directly on the Pebble-Beds. C. H. C.

KEUPER SANDSTONE.

The Keuper Sandstone consists in the main of beds of red and white, and less often brown or yellowish, sandstone separated by thin bands of red and mottled marls. The sandstones are generally false-bedded and locally micaceous. The most common mica is white; where brown mica was present it is now altered to green chlorite. Felspar is an important constituent of the lowest beds. In many of the beds, especially near their base, pellets of red or green marl are fairly common; these also are most abundant in the lower beds. The sandstones are calcareous and often weather with a pitted or honeycombed surface due to superficial dissolution. Pebbles, generally of white quartz or quartzite, are scattered through many of the bands, sometimes in lines, occasionally in small lenticular patches or pockets. At or near the base there is often a distinct bed of conglomerate, presenting a greater variety of pebbles, Carboniferous limestone and chert being found locally, and occasionally some small fragments of igneous rocks. Some of the pebbles that have been derived from the Bunter show the character of surface produced by wind action.

The texture of the ground-mass is on the whole finer than that of the Bunter Sandstones, but fairly coarse bands may be met with in any part of the middle and lower beds; in many cases the grains, especially the larger ones, are well rounded as if wind-worn; in others they are angular.

The lower sandstones, and especially the lowest, generally contain a considerable number of small pebbles and grains of fresh pinkish felspar, which break along the cleavage-planes and readily catch the eye by their glistening surfaces. In no other rock in this area do these felspars occur in such abundance. Towards the top of the sub-division the sandstones become finer in grain, more micaceous and more evenly and thinly bedded, while the marl beds steadily thicken, a gradual change being thus effected into the Keuper Marl. These passage-beds, which are of no great thickness, appear to correspond to the Waterstones of Cheshire and other regions.

The Keuper Sandstones, mostly free from drift, cover an area in the centre of the district, with a maximum breadth from east to west of about 8 miles and from north to south of about 7 miles. The smaller outcrops occur farther north, one at Brereton, the other at Armitage; to the south the commencement of a large outcrop is shown near Little Aston, a small inlier being exposed along the sides of a stream a little to the east; while in the south-eastern or Warwickshire coalfield area are a number of small detached patches in which the Keuper Sandstones are either banked against or rest directly on Palæozoic rocks without the intervention of either the Bunter or the Hopwas Breccia. G. B.

DETAILS.

The main outcrop of the Keuper Sandstone forms an undulating ground rising generally to the west and attaining an elevation of about 550 ft. close to the boundary-fault at Chase Terrace. The northern boundary is free from faults of importance, and sinuous, the dip being low; the southern boundary is more faulted. Along most of the eastern margin and much of the southern the Keuper Sandstone rests directly on the Pebble-Beds, but westward of Wall, Upper Mottled Sandstone intervenes. E. E. L. D.

The Maple Brook boring, of which the details are given on p. 274, commenced about 20 ft. below the top of the Keuper Sandstone and reached its base at a depth of 200 ft. The sandstone was similar to the Bunter Sandstone below it except in being somewhat finer in texture. The dominant tint of the cores when fresh was red-brown, but there were some mottled and pale-green bands. All, however, tended to become grey externally when exposed to the air. In Bunter Sandstones little change is observable under similar circumstances. A bed of conglomerate 2 ft. thick of a dull reddish-brown with green mottling occurred about 25 ft. above the base. The grains were coarse, often well rounded and cemented by carbonate of lime. The pebbles varied from well-rounded and smooth to subangular, and a few were well pitted; one had the form of a dreikanter. A pebble of crinoidal limestone was found, but the small pebbles and large grains of pink felspar usual at this horizon were rare or absent, though they appeared in a conglomerate band a few inches thick, 10 ft.

lower down. Below this was a bed of marl 2 ft. thick overlying about 10 ft. of red-brown sandstone of medium grain, without pebbles, similar to the beds higher up. Below this only loose sand without pebbles, which was taken to be Upper Mottled Sandstone, was brought up. All the rocks were calcareous. In most cases the carbonate was uniformly distributed and not uncommonly it occurred in optically continuous sheets; in others it had formed concretions of 'race,' some of which had been dissolved, even in cores taken at a depth of 150 ft. Micas were fairly abundant, especially in the sandy marl-partings; brown mica was not uncommon, but had always been altered to chlorite.

At Lichfield the section laid open along the railway between the Trent Valley and Town stations shows typical current-bedded, red-brown and reddish sandstones, often with pellets and pebbles. Most of the beds are calcareous, and some show nodular concretions which are rather unusual in having crystalline centres and fairly defined margins; they appear to be partly dolomitic. Similar beds are seen in a road-cutting about 150 yards to the north. The dip is gentle in a westerly direction. South of Lichfield and close to the railway junction at Sandfields there is a sand-pit in decomposed sandstone containing, among other pebbles, fragments of igneous rocks and what appear to be agates.

A little further south, close to Knowle Hill, a railway-cutting shows some sandstone cemented by crystalline calcite and containing abundant marl-pellets. A marl-parting shows that the dip amounts to 5° or 8°, an unusually high inclination which is probably due to a fault a little to the west that brings up the small inlier of Bunter shown on the map.

The railway-cutting at Pipe Hill shows a section nearly a quarter of a mile long, in which, in addition to the normal sandstones, there is a pebble-bed with a marly matrix and a group of marls from 10 to 12 ft. thick. The dip here is quite low, in a south-easterly direction. The cutting is crossed by a fault, the throw of which could not be ascertained.

About a mile to the north-west of Lichfield, by the side of the southern of two roads that meet at an acute angle, there is a continuous section of sandstones with scattered pebbles. To the south of this, at Abnalls, a roadside-section exposes similar rock with some thin conglomerates. Many of the pebbles show fretting, such as is produced by wind-action, and one dreikanter was found *in situ* here.

At Hammerwich Station the section in the railway-cutting which in 1859 exposed nearly the whole of the Lower Keuper Sandstone,[1] shows some of the lowest sandstones of normal type resting on a conglomerate about 5 ft. thick, in which the bulk of the pebbles are as rounded as those in the Bunter and are composed of similar materials. Some of them show pitting. This bed is not the base of the Keuper, as was formerly supposed, for it rests on 5 ft. of hard, brick-red, fine-grained sandstone, part of which is calcareous and contains abundant marl-pellets ('cat-brain') associated with a few pebbles. This in turn is underlain by 2 ft. of red marl that throws out water. There is a break of a few yards in the section, but further west the red sandstones alternate with thin bands of coarse, angular-grained, brown sand-rock containing small pebbles of quartz and felspar. Some soft loamy sands seen at the base of the west end of the cutting doubtless represent the Upper Mottled Sandstone, but the junction with the Keuper is not now visible.

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[1] 'The Geology of the Warwickshire Coalfield,' *Mem. Geol. Survey*, 1859, p. 37.

The basal beds below the conglomerate are seen again in a steep bank by the roadside, about half a mile westward of the church, but the actual junction with the Upper Mottled Sandstone is overwashed.

At Hints the best exposure of the basal conglomerate in the district occurs at the post-office on the Watling Street. The rock is false-bedded and contains fragments of quartzite similar to that of the Bunter pebbles. Some of the fragments are well rounded, but the larger ones are at times as angular as those of the Hopwas Breccia. Pebbles of Carboniferous Limestone are easy to find, and there are several of a hard, green rock, believed to be pre-Cambrian rhyolite. Pink felspars are particularly noticeable. The rock is firmly cemented by carbonate of lime. The Keuper here rests directly and sharply on the Pebble-Beds, and there is clearly no Upper Mottled present. G. B.

The sandstones which overlie the basal bed occur in a small lane close by, and the sandstone with small pebbles is often visible at the west edge of a plantation to the north; they are deep-red brown in colour and closely resemble Bunter Sandstone.

E. E. L. D.

A small but clear exposure occurs in an old quarry 400 yards south-west of Packington Hall.

A small prolongation of the main outcrop forms a scar composed of reddish brown, false-bedded sandstone close to the Tame alluvium at Tamhorn House Bridge. Small lenticles of coarser grain project from the weathered faces, the lime having been more readily dissolved from the finer parts. The coarser rock, a little in from the surface, is so markedly calcareous that a freshly-fractured specimen is pale pinkish-white. In it grains and small pebbles of pink felspar are abundant, and at times a third of an inch long. The outcrop lies between two branches of the Hints fault, which here is splitting up. The scar-face is traversed by several minor fractures. G. B.

Near Whittington, beds high up in the Lower Keuper Sandstone are exposed in several road-cuttings in and round the village. They consist of hard, massive, false-bedded sandstones, with occasional beds of red marl. The sandstones are often extremely coarse and contain small pebbles, especially of white vein-quartz. In some places the pebbles are so large and numerous as to constitute a conglomerate, such as was found in a sewer where the canal crosses the Elford road. The matrix here was a coarse, light-brown, felspathic sandstone with a calcareous cement. It contained pebbles of vein-quartz, quartzite of the Bunter type, crinoidal limestone, and pellets of red marl, many reaching a length of 3 in. Large, rolled crystals of light-brownish felspar, often $\frac{1}{4}$ in. to $\frac{1}{3}$ in. in length, occurred also in fair abundance. These crystals are to be found in all the coarser bands of the Keuper Sandstone, but are, as a rule, more typical of the lowest beds. The rock was interbedded with coarse, friable, white sand-rock, passing beneath a series of fine-grained red sandstones, alternating with red marls, which become increasingly abundant upwards in the series. The highest beds of the Lower Keuper Sandstone are exposed for 10 ft. in an old quarry behind Fisherwick Dairy Farm, where they consist of rapid alternations of yellow or red, fine-grained sandstones and red marls. None of the sandstone-bands are thick, and red marl is predominant. C. H. C.

A little west of Whittington, on the roadside near the Ordnance mark 278, a good section of the sandstone without pebbles shows well the varying coarseness of the texture and the roundness of the larger grains. At Quarry Hill, close to the Whittington and Lichfield road, there is a group of quarries. The lower sandstones are deep red-brown and practically indistinguishable from Bunter; the upper are lighter in colour and more markedly false-bedded; they contain also many pellets and pebbles, some of which are of calcareous sandstone, possibly derived from some older formation. Generally a thin marl separates the lighter and darker beds, but it appears to thin away eastward.

The marl-partings associated with the middle and lower beds are rarely seen except in artificial openings; in several places they have been used for marling, and more rarely for making bricks and tiles. They are thin, and apparently were worked because no thicker band was available. About a mile to the west, and due north of Weeford, there are old pits occupied by plantations, and 100 yards W.S.W. of the barracks there is an old brick-pit. On the eastern side of the railway, near the junction of Rykneld Way and Watling Street, red laminated marl is visible in an old excavation. E. E. L. D.

Close to Armitage Church, in the bank of the canal, the sandstones with marl-partings are traversed by four faults in a space of about 20 yards. The westernmost fault throws the beds up some 3 ft., while the second throws them down 4 ft. The beds between consist of 8 ft. of grey and yellow sandstone with a honeycombed surface, containing small pebbles. This rests on 3 ft. of coarser rock, with marl-pellets. At the base, which is uneven, is a band of marl about a foot thick, passing down into sandstone, red at the top but grey below, exposed for 5 ft.

The third fault has a down-throw greater than the height of the bank, and brings in several feet of red marl resting on 6 ft. of rather hard, fine, grey sandstone, with red joints, below which are alternations of red marl and thin sandstone. This fault is shown on the map. The fourth fault has a small upthrow to the east.

The sandstones about Armitage are bounded on both sides by faults which unite further south and terminate the outcrop. About Brereton Cross, on the west side of the western branch, they rest naturally on the Bunter, with the sinuous margin prevalent in the northern outcrops. The lowest beds contain the grains and small pebbles of fresh felspar already referred to, while larger and generally subangular pebbles of vein-quartz and quartzite are common. The basal bed, where visible, is a conglomerate. The best exposures are in and about the roads at the south side of Gorsy Bank. E. E. L. D.

On the southern outskirts of Rugeley, fine-grained yellow and pale-red sandstone, close to the top of the Keuper Sandstone, is exposed along the Brereton and Armitage roads at the Marlpits and at Mossley. Lower beds emerge from the drift south of Brereton, where the best section is afforded by a disused quarry a quarter of a mile south of the Springs Farm, which shows 15 ft. of red and greyish-yellow sandstone with subordinate beds of red marl. These marl-bands were formerly used for brick-making. What is possibly the same group of marl-bands was once worked for bricks, through the cover of Glacial drift, in the allotment ground north-west of Brereton Church. This was formerly regarded as a faulted outlier of Keuper Marl.

Farther south a narrow outlier of the basement-beds at Upper Longdon presents no sections. Still farther south a narrow strip of higher beds is thrown in by an east-and-west fault with southward downthrow in Beaudesert Park. A quarry[1] at the electric-light works, 200 yards north-west of the Hall, shows 6 ft. of red marl (the lowest part of the Keuper Marl) resting on 18 ft. of soft, fine-grained, light-grey sandstone, overlying micaceous red sandstone. The grey stone was being raised in 1910 for interior work at the Hall. Smaller sections in lower beds can be found between the quarry and Horsepasture Covert, and also east of the Hall; close to the stables some of the beds are pebbly, while others are heavily charged with mica.

South of the thickly drift-covered Marl ground of Gentleshaw the uppermost beds of the Lower Keuper Sandstone, though obscured by drift, can be seen at Coldwell (in the valley east of Gentleshaw), at the Nun's Well and on Old Lodge Hill, and also in some old quarries between Red Moor and Boney Hay; also in the valley east of Chase Terrace, and about Chasetown and thence toward Hammerwich. There are, however, no good sections, as the stone is usually so weathered, soft, and deficient in cement as to be useless as building material. Immediately below the Keuper Marl the sandstones are usually buff-coloured or pale brown, but become coarser and pebbly at lower horizons. A band of red marl in the sandstones has been utilised for brick-making in Brick-Kiln Slade, east of Chase Terrace; while loamy, dark-red sand-rock is exposed under drift gravel in a pit on Ball's Mount, and has been dug for building-sand at Spring Hill close by. T. C. C.

From Four Oaks through Sutton Coldfield there runs a long strip of Keuper Sandstones bounded by faults except near Moor Hall, where they dip eastwards beneath the Keuper Marl. The lower part of the series consists of hard, massive, coarse-grained sandstone with little clayey matter, but higher up marl-bands become more numerous and the sandstones more finely grained. The lower beds are well exposed in the railway-cutting at Four Oaks Station, where for 20 ft. they consist of massive, coarse-grained sandstone with small pebbles of white vein-quartz and felspar. Felspar pebbles are particularly abundant in the Sutton district, and serve to distinguish the Keuper from Bunter Sandstones.

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[1] Survey Photograph No. 1543.

The higher beds are nowhere well exposed in the Sutton area as comprised in Sheet 154, but southwards they are well seen in the old quarries at Reddicap Hill, where they consist of fine-grained red sandstones alternating with red marls. Here, however, the highest beds are absent through faulting, while further north, at Moor Hall, where they are present, the exposures are too poor to give an idea of their nature. C. H. C.

An inlier of Keuper Sandstone, occupying about 100 acres, is found at Ashfurlong Hall, about a mile and a half north-east of Sutton Coldfield, on the Tamworth Road. It is bounded on the east by a fault which runs from near Fox Hill House to Barn Farm, but on the north-east, west and south it shows natural junctions with the Keuper Marl. A line of overgrown quarries runs through Wheatmoor Wood and in a spinney on the opposite side of the Tamworth Road soft, creamy, micaceous sandstone, dipping eastwards at about 5°, is visible to a thickness of 5 ft. The western boundary runs partly under alluvium and across the road to Wheatmoor Farm and Wheatmoor Plantation. An old quarry on the south side of the road is partly filled with water, but shows red sandstone, somewhat harder and more finely-grained than that in the spinney. The grains, chiefly of quartz, are subangular and of uneven size. Little mica is present.

T. E.

In the neighbourhood of the Warwickshire Coalfield the Keuper Sandstone in places rests upon or is banked against Cambrian or Carboniferous rocks, but along much of its outcrop is faulted against beds high up in the Keuper Marl. The throw of the fault, however, diminishes northward as the Western Boundary Fault, described on p. 158, splits up. The most southerly exposure occurs a little above the alluvium of the Tame, near the southern edge of the map, but a more instructive section is afforded in a bank just south of the tip-heap from the Dosthill Quarry. Here in the roots of trees the sandstone can be seen to cling to a steep slope of Cambrian shales. It contains no visible particles of the adjacent rocks, but is deeply stained with iron, doubtless by infiltration from the decomposed igneous rocks close by. For a short distance to the north the slope consists of Cambrian rocks, but at Wigford Farm a pit has been opened in loose brown sand, resulting partly from decomposition of the calcareous Keuper Sandstone *in situ* and partly from the downwash of the hill above. The sandstone-outcrop here widens out and the soil consists of a soft brownish sand, which contrasts strongly with the grey, clayey soil of the Coal Measures to the east. It is to be noticed that the Keuper here occupies a bay, cut into the Cambrian at a point where resistent igneous rocks and the associated hardened shales happen to be absent. In this sheltered recess fine sandstone and marl were deposited, as may be seen in small openings at the southern end. On the steep face of a hollow below Dosthill Lodge numerous large rounded stones associated with sand are seen by the side of the farm-road, suggesting that pebbles were included occasionally in the sand that once filled the hollow, and the suggestion is supported by the occurrence of similar pebbles in a conglomerate seen in situ on the east side of the Cambrian outcrop near the Lodge. This is best seen at a gate by the footpath to the Fox Inn. The matrix is yellowish-brown, somewhat ferruginous, and contains also much clayey material, probably comminuted Dosthill shales. The majority of the pebbles are of vein-quartz, subangular, and among them are a few as large as a man's head. Vein-quartz and quartzite are the most common, but there are also rounded pebbles of Cambrian Sandstone, not now visible in the hill itself, and also of fine-grained, acid igneous rocks with quartz-crystals such as are unknown in the area. Several other small patches of conglomerate are to be found about the side of a lane near the old church, and the loose pebbles have a still wider distribution. The position of the conglomerate in the Keuper has been a matter of doubt, but there is no doubt that it is the local base of the sandstone which once wrapped round the Dosthill-Cambrian inlier just as the Carboniferous rocks had done at an earlier epoch. Not only was a large part of this Carboniferous envelope removed, but the Cambrian rocks themselves were further eaten into before the Keuper Sandstone was deposited against them.

The sandstones continue northward to Dosthill House, where they form a low bank on the river-edge, and at one point a bare scar. They are coarse in the main, reddish-brown when weathered, with green marl-pellets and scattered subangular quartz-pebbles. In the coarsest portion, which is highly calcareous, the distinctive pink felspar-pebbles are abundant though mostly small. In a garden above the bank the beds are finer and associated with red marl-beds, which leaves no doubt that the rocks are of Lower Keuper age. To the north of Dosthill House the marls and fine sandstones continue in a gradually narrowing outcrop as far as the Fazeley Bridge. It is worth mentioning that most of the outcrops in this part of the area are so overwashed by grey clay from the Coal Measures that even the existence of the Keuper could be ascertained only by digging.

South of Dosthill House the narrow outcrop about the river-banks yields a large volume of pure water, but at Dosthill House there is both a brine spring and a chalybeate spring (p. 222). To the north of Fazeley Bridge the Keuper Sandstone, here banked against Keele Beds, is not visible unless the ground be cut open. It is probably present a little north of the bridge, and emerges above the alluvium at Kettlebrook on the north-western and northern sides of the village. Specimens taken out in making the sewers here were available, and some information as to the extent of the rock was obtainable at the time of the re-survey, but its outcrop is everywhere covered by drift or downwash. It continues as a narrow belt to the viaduct just south of Tamworth, where it was being excavated. From the edge of the alluvium, close to the Isolation Hospital, an excavation for a sewer, made straight up the hill towards Amington, showed at the lowest end a thin cover of drift resting on Keuper Sandstone, a pale-yellowish, slightly micaceous and moderately coarse sandstone, which was not bottomed at 14 ft. and except for a few red and highly micaceous films was of the same colour and texture throughout.

It had been calcareous, but near the surface was decalcified and the fragments taken out soon crumbled to an almost white sand. The dip was gentle to the N.W. At 100 yards from the alluvium a band of large, more or less isolated pebbles or small boulders was met with, the majority consisting of quartz and quartzite, both well rounded and subangular. Of the two largest seen, one consisted of chert, the other of Keele Sandstone, identical with a rock seen farther on and probably derived from it. Farther up the hill the base of the Keuper Sandstone was laid open and the trench passed into Keele Marl. The unconformable junction was clear; the dip of the Keele Beds was 12°, whereas the Keuper Sandstone was nearly horizontal, and the contrast in appearance was no less striking. None of this outcrop is visible at the surface.

Farther north the evidence is scanty. A boring at Moor Farm, shown on the map, was in Keuper Sandstone, while an outcrop of marl shows the low hill of Royals Farm to be formed of Keele Beds, but in the bed of the river, at the bridge of Amington Hall, there is an outcrop of Keuper Sandstone. The sandstones, still banked against the Keele Beds, must partly circle round the hill of Royals Farm and continue eastward till they are cut out by the upthrow fault shown on the map. That the junction has continued to the north is shown by its emergence at the Ashby road, where the Keuper Sandstone occurs as a small triangular wedge, lying between the Western and Eastern Boundary faults of the coalfield, the base of the triangle being an unfaulted boundary of Keuper Sandstone either resting on or banked against Keele Marl. A quarry on the north side of the road shows the pale sandstone, with scattered subangular quartz-pebbles and many small pebbles or large grains of the typical pink felspar. This is the most northerly of the outcrops in which both the Bunter and the Hopwas Breccia are absent. There must be a pre-Triassic bank here sloping steeply northwards, for at Lullington Hall, 4 miles away, the two together attain a great thickness, and if the details of the boring are reliable, the pre-Triassic surface has descended possibly 1,000 ft. The outcrop last described leads on to localities where Keuper Sandstone rests on and is not banked against the older rocks. On the west side of the eastern of the two faults, about 600 yards south-east of Shuttington House, an outcrop, not more than 50 yards long by 20 broad, shows loose white sand, through which are plentifully sprinkled the usual grains of pink felspar. The Bunter Sandstone here also is absent, though it is well developed eastwards near Polesworth (in Sheet 155), and has been recently proved to exceed 236 ft. in thickness in a boring (p. 282).

A small patch of Keuper Sandstone lies on the eastern side of the fault. It is nowhere actually exposed, but some little digging revealed the fine red sandstones and marls which constitute its upper part. Farther south, near Glascote, there is an outlier[1] of the red-brown Keuper Sandstone, lying on a hill on the south side of the Glascote road. It rests on grey Coal

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[1] On the former map this was shown as Permian (now Keele Group).

Measures and its former extension to the south is shown by a bank which terminates the outcrop of the Halesowen Sandstone. The bank runs at right angles to the strike of the bed, and appears to be a relic of the Keuper Sandstone margin.

The last of the small outliers is too small to be shown on the map, and, moreover, it has been seen only in a temporary opening. When a sewer was being made at the Rural District Board's depot, on the east side of the Kettlebrook road, where it is crossed by the northern of the two faults, grey Coal Measure clays, terminating abruptly against red Keuper Sandstone with small quartz-pebbles, were open to view. The sandstone appears to occupy a small hollow eroded along the line of fault and owes its preservation solely to its sheltered position. G. B.

KEUPER MARL.

The Keuper Marl near its base consists of red cuboidal marl alternating with more clearly-bedded, sandy, green, red and grey material associated with thin, hard, fine-grained sandstones, or 'skerries.' These bands are generally dolomitic, and often show salt-pseudomorphs on one surface. Upwards the sandy and bedded material becomes scarce. The full thickness of the Marl is nowhere seen, but it must be not less than 500 ft. in the north-eastern corner of the area, while a little south of Moxhull New Hall (Sheet 168) at least 700 ft. were proved in a boring. Wherever they were accessible, the marls used to be dug for spreading over the land, but most of the pits now serve as ponds. The marls are occasionally used for brick-making.

These marls cover a considerable area in this map, and extend far beyond it to the north, east, and south, but are partly overspread by the deposits of the Trent and the Tame. That they once were more continuous than now there can be no doubt, but they have been denuded except in the area between the two coalfields, and even from this they have been removed from a low dome of elevation on the north-western side of the Hints Fault.

In the area on the southern side of the Trent, above its junction with the Tame, the oncoming of the marls is usually marked by a rise in the ground, or even a small escarpment. Only the lower beds are present, and a few of the old pits show the presence of sandy bands near the base. G. B.

The marls, though largely concealed by drift, form the higher parts of Beaudesert Park, their actual base being visible in the sandstone-quarry near the electric-light works already mentioned (p. 147). They may be seen also in old brick-pits and excavations in the valley draining southward from Castle Ring, and again in old pits on Red Moor, where the boundary-fault, which here separates them from the Coal Measures, can be located with precision (p. 164). T. C. C.

About and to the south-west of Longdon there are old pits of little interest, but to the south-east, at Cleat Hill, a pit shows 15 ft. of the marl with laminated beds, while a well close by passed through 40 ft. of similar material before reaching the Keuper Sandstone.

To the north at Armitage, the pit at the Brick and Pipe works shows 10 ft. of the red marls and laminated beds, traversed by several small faults, probably diverging from the larger one shown on the map.

North-west of Lichfield, at a sharp bend in the outcrop of the marls, an old brick-pit, some 25 ft. deep, shows the basal beds composed mostly of the red cuboidal marl, in which are included thin bands of shaly green-grey marl, associated with thin, fine, brown current-bedded sandstone, containing salt-pseudomorphs. These bands are about 4 ft. apart and the thickest is about 15 in. The pit is close to the fault shown on the map, and the beds are almost vertical near the fault, but quickly flatten further from it. A well here is said to have been dug in the marls, and a boring was made below it, but no details could be obtained. Here and in several other places calcareous nodules have occasionally been met with in association with the calcareous sandy bands.

A little N.W. of Brown's Fields, 1 mile N.E. of Lichfield Station, the lower beds of the marl may be seen resting on Keuper Sandstone. Near Streetly an exposure at Hill Farm shows red marl interlaminated with thin green sandstone resting on fine-grained red Keuper Sandstone, while another, a little to the north-east, is in higher beds and shows a diminution in sandy and laminated material. Still farther north, at an old brick-pit at Hilliard's Cross, only red clay is visible. E. E. L. D.

To the north of Whittington, though there is little drift, there are no clear sections. The oncoming of the marls is marked by low escarpment, striking N.W. and S.E. In the direction of the dip a well close to the railway at Fradley proved a thickness of 170 ft. of the marls (p. 275).

On the east side of the Tame the marls are mostly free of drift and form a gently undulating tract seldom exceeding 300 ft. in altitude. Associated with them are thin lenticular bands of grey or reddish sandstone of fine texture, and some bedded sandy marl. The roadside banks south of Walton and west of Walton Hall show brown sand derived from decomposed sandstone-bands in the marl. To the south of Walton, at Borough Hill, 'skerries' from 2 to 3 ft. thick occur as lenticles in the marl and are associated with some fine fissile sandstone. A pit close to the lodge to the north of Coton Hall also shows some sandstone with the marl, while a quarter of a mile to the south-east of Fairfield a scar in a field is formed of some 7 ft. of marl associated with grey material not only in thin bands, but also in strings and cores. The occurrences of sandy material are suggestive of a representation of the Upper Keuper Sandstone. There must here be a considerable thickness of the marls; they were penetrated for 400 ft. at the Lullington boring (p. 155). J. B. H.

Over this large area the dip is usually low, but to the south of Harlaston, in a belt of ground some 100 yards wide, it reaches 10° to 12° in a south-westerly direction. The belt lies on the line of the Hints Fault and may be connected with it. At Elford Low Farm the marls were penetrated to a depth of 200 ft. without reaching their base. South of Elford, in the river bank at The Cliff, there is a good deal of shale and thin skerries associated with the marls.

Near Tamworth more of this sandy material is seen in the lower beds which were laid open to a depth of 20 ft. in the Midland Railway-cutting on the north side of the Ashby road. Red cuboidal marl here alternates with red and grey shale containing two thin bands of fine-grained grey sandstone (skerry). Embedded in the shale occur nodules of hard skerry-like material often reaching 3 to 4 in. in diameter. These run in layers and the laminæ curve round the nodule. The skerry-bands contain dolomite and are associated with much grey shale. C. H. C.

An almost identical but more accessible section occurs in a cutting on the south side of the road, made for a junction of the two railways, but at present abandoned. Here the skerries show well-formed salt-pseudomorphs.

The well at the brewery close to the bridge over the Tame at Tamworth penetrated about 100 ft. of marls, in which sandy bands and skerries are reported to have occurred throughout. The composition of the artificial hill on which Tamworth Castle stands, and which presumably was formed of the material dug out of the great 'dyke,' indicates that much sandy material is present in the lower beds of the Keuper Marl. G. B.

The outcrop of Keuper Marl in the southern part of the map is traversed by several deep-cut stream-courses, and in the banks thus formed pits could be dug without being waterlogged. The steepest bank is on the side of the Bourne Brook to the south of the Watling Street, and near Bangley House there are several pits giving good sections. They show that there is little sandy or bedded material in the red marl and that skerries are rare, from which it may be inferred that we are here dealing with the higher part of the Keuper Marl. About Drayton Bassett the pits are all obscured, but farther south about Middleton there are several other sections; one at the west end of the village exposes 12 ft. of marl with a band of skerry, but in none is there any appreciable amount of bedded sandy or shaly material. At Moxhull New Hall (Sheet 168) a boring penetrated more than 700 ft. of marl without reaching the base.

To the south-west of Middleton a pit near Hill Farm shows green spots (fish-eyes) in the marl; further west, in the New Park Wood area, a section by the roadside near the south edge of the map shows shaly material suggestive of the lower beds, and the actual base is exposed in a small valley at Ashfurlong Hall. In this south-western part of the large outcrop the dip is small in a north-east direction, at times inappreciable. The marls are well exposed in Mark Lloyd's Brick Pits, Whitebourn Common, where the following section is visible:—

		Ft.	In.
Drift—Unbedded sands and gravels...		3	0
Keuper Marl	Red shaly marl and grey shale, alternating with skerry-bands ½ to 1 inch in thickness...	4	0
	Red cuboidal marl, often passing into grey marl	8	0
	Blue-green shaly skerry ...	0	9
	Cuboidal stiff red marl passing into grey marl	8	0

When freshly quarried the skerries can be powdered between the fingers, but they quickly dry into a tough, hard rock. Salt-pseudomorphs are common on the underside.

At the Wheatmoor Pit the lower beds are again exposed, and here consist, as before, of cuboidal marl with considerable development of shale and skerry. This pit, however, is only worked intermittently and the section is partly obliterated.

Towards the Hints Fault some pits near Great Bangley show a moderate amount of shaly material and some skerry, still low down in the marl, but about Hints sandy and shaly beds appear to be rare.

It seems, therefore, that the development of shale and skerry, here as elsewhere is more pronounced in the lower beds and that higher in the sequence the cuboidal type of red marl predominates.

On the east side of the Tame, near the southern edge of the map, there commences a large outcrop which extends far southwards. Sandy bands are common, and are fairly well seen in the river-bank 200 yards below Cliff House. The dips all over this outcrop range as high as 10° to 15°, the beds rising sharply toward the fault. At the sewage-works, in the bank of a small stream close to the railway, some sandstone was turned up which may be the top of the Keuper Sandstone.

G. B., C. H. C., T. E.

LULLINGTON BORING.

During the years 1876-1880 a boring was made on the west side of Lullington Hall, situated close to the eastern edge of the map, about 6 miles N.E. of Tamworth. It was carried to a depth of 1,190 ft. without reaching the base of the Trias, and the cores brought up from the lower part showed that the Bunter differed considerably from the typical Bunter of the district here described, as did also the part of the Keuper Sandstone immediately underlying the Keuper Marls. Some doubt has been felt as to the reliability of the record, which, however, is probably correct. The difficulty in accepting the record arose from the fact that the upper part of the Keuper Sandstone, for at least 100 ft., consists of soft sandstones, sandy red marls and marls in alternating layers, strata which have no precise equivalent in the numerous borings in the rest of the area included in Sheet 154, for though similar beds occur in this position they are quite thin. But in the area to the east (Sheet 155) alternations of sandy and marly material commonly attain a thickness of 100 ft. or more. The interpretation of the boring therefore hinges upon a comparison with some section in the eastern area within reasonable distance. The nearest is that made at Chilcote, of which the section is given in the Memoir on the Leicestershire and South Derbyshire Coalfield, 1907, p. 331. If the two sections are compared it will be found that the softer portion of the Keuper Sandstone coincides, but that the underlying beds are at least 100 ft. thicker at Lullington than at Chilcote. It is not easy to say exactly where the Bunter begins in either case, but some thin conglomerate-beds occur at much the same horizon in both. At Chilcote there is the usual development of thick Pebble-Beds in the lower portion, the lowest thick bed resting on the Hopwas or Measham Breccia with the ironstone-measures (base of Coal Measures) below.

But at Lullington these Pebble-Beds are feebly developed, being replaced by coarse, often red, sandstones. The mode of occurrence of the Bunter gives the key to the cause of this difference; at the north end of the Warwickshire Coalfield there is no Bunter, and the same is true of the South Derbyshire Coalfield north of Measham, but between the two there lies a pre-Triassic valley filled with Pebble-Beds, the margins of which lie near Polesworth on the S.W. side and about Overseal and Donisthorpe on the north-east. The coarse Pebble-Beds seem to be fully developed only near the margins; away from the margins, in the deeper part of the valley, the material deposited was finer in grain though of greater thickness. There is thus no longer any reason to doubt the general accuracy of this boring, which is important, as probably the entire thickness of the coal-bearing measures underlies the Trias at this point (pp. 174, 175).

A similar change in the Bunter takes place as the formation is traced from the Shenstone area, southwards towards Birmingham.

The details of the Lullington Boring are given in the Memoir referred to, and a brief summary only need be given here:—

		Thickness.	Depth.
		Ft.	Ft.
Keuper	Marls with gypsum, etc.	400	400
	Alternations of sandy marls, marls and soft sandstones	188	588
Probably Keuper.	Conglomerate 19 ft., succeeded by hard marl and much red sandstone, etc.	132	720
	Conglomerate (sandstone with angular fragments)	10	730
Bunter.	Coarser sandstones, etc., with some conglomerate near top	460	1,190

G. B.

CHAPTER VIII.

FAULTS AND EXTENSIONS OF THE COALFIELDS.

FAULTS.

Although the importance of the faults lies mainly in the displacements they produce in the coal-seams, their effects in the Triassic rocks require consideration; in so much as many of the comparatively small movements of post-Triassic age have taken place along the same general lines as those of pre-Triassic age.

NORTH WARWICKSHIRE COALFIELD.

By G. Barrow.

In the Old Series one-inch maps the northern part of the known Warwickshire Coalfield was shown as being bounded on both sides by faults which intersect at the extreme end of it. These faults form respectively the Western and Eastern Boundary Faults. Their position as shown on the present maps does not differ materially from that shown on the Old Series Maps, except in some local modifications. The most important alterations are due to the recognition that the red marls and sandstones on the western side of the coalfield are mainly of Keele and not of Keuper age, as was previously supposed.

It was understood that the boundary-faults did not terminate the coal-seams, but merely threw them to such a depth that they were inaccessible from the existing shafts. The downthrow was not known, but now not only has the age of the beds at the surface on the downthrow-side been ascertained, but the identification of a Spirorbis-limestone, which lies about 140 ft. up in the Keele Group, has enabled the approximate horizon in those beds to be fixed with considerable accuracy. The exact amount of the throw is, however, still locally difficult to estimate, as there is great variation in the thicknesses of the underlying groups—the Etruria Marls and the Middle Coal Measures. The variations of the latter take place in a fairly definite direction, but the changes in thickness of the Etruria Marls are more capricious.

The dip of the strata on either side of the faults is liable to great variation. In some cases it is steep or almost vertical on both sides; in others it may be quite low to within a few feet of the dislocation on the one side, but is vertical on the other side. It is rarely, if ever, low on both sides of the fault. Where it is nearly vertical on both sides the structure may be regarded as a compressed anticline cut through by a fault, the displacement of which cannot be measured. The only useful measurement that can be made is the aggregate displacement due to the disturbance as a whole. This gives the *effective throw* of the fault from a miner's point of view.

Evidence obtained at the surface has proved that this effective throw often keeps nearly the same for considerable distances, though the displacement at the fracture-face varies incessantly, owing to the variation in breadth of the belt of steeply-dipping rocks. Outside this belt, especially on the downthrow-side, outcrops may keep parallel to the fault for a mile or more.

The Western Boundary Fault.

The workings at Kingsbury Colliery have shown that on the upthrow-side of the Western Boundary Fault the beds keep a low dip to within a short distance of the fracture, but then turn up sharply—almost to verticality. On the downthrow-side also they are almost vertical but inclined in the opposite direction, so that the structure here is a compressed anticline cut through by the fault. The compression may be attributed to the resistance offered by the upstanding mass of Cambrian and igneous rocks of Dosthill. It is not manifested much beyond the northern margin of that mass.

A series of small trial-holes was made in the belt of steeply-dipping rocks on the south side of a small stream, close to the junction of the two railways, near the southern edge of the map. From one of these, situated at the eastern foot of the railway-bank, a typical pellet-sandstone was brought up which may be identified as the bed above the lowest Spirorbis-limestone in the Keele Group. The strata dipped at a high angle westward, that is toward the downthrow-side of the fault. In a field close by the lower part of the Etruria Marls crops out at the surface, so that at the fault-face the total displacement is equal to the thickness of the greater part of these marls added to that of the Halesowen Group and about 150 ft. of the Keele Group, or roughly 700 ft. But in view of the structure this does not represent the effective throw, which can be calculated as follows: Not far from the trial-hole the depth to the Rider Coal is 700 ft. added to the thickness of grey measures above this seam, or 880 ft. in all. The top of the hole is about 230 ft. above sea-level, and the seam consequently about 650 below sea-level. In the mine close by the seam lies at 250 ft. below sea-level, just before the sharp rise sets on, so that the effective throw between the two points is 400 ft. The discrepancy between the two throws is due solely to the uprise toward a downthrowing fault, which, so far as effective throw is concerned, can be ignored.

Unfortunately the final effective throw must be increased, firstly by one or more downthrow faults further west, which bring in Keuper Marl, and which can hardly have a displacement of less than 100 ft; and, secondly, by the steep westerly dip in the Keele Beds on the downthrow-side of the main fault.

At the Streetly borehole (p. 62) the Hamstead Beds were not bottomed at a depth of 1907 ft. The effective throw of the Boundary Fault would appear therefore to be made up of a minimum of roughly 400 ft. for the easternmost fault, at least 100 ft. for the fault farther west, while not less than another 100 ft. must be added for the effect of the dip. Thus for the purposes of coal-mining the effective throw can hardly be less than 600 ft.

and may be more, but its actual amount could only be settled by boring through the Keuper Marl.

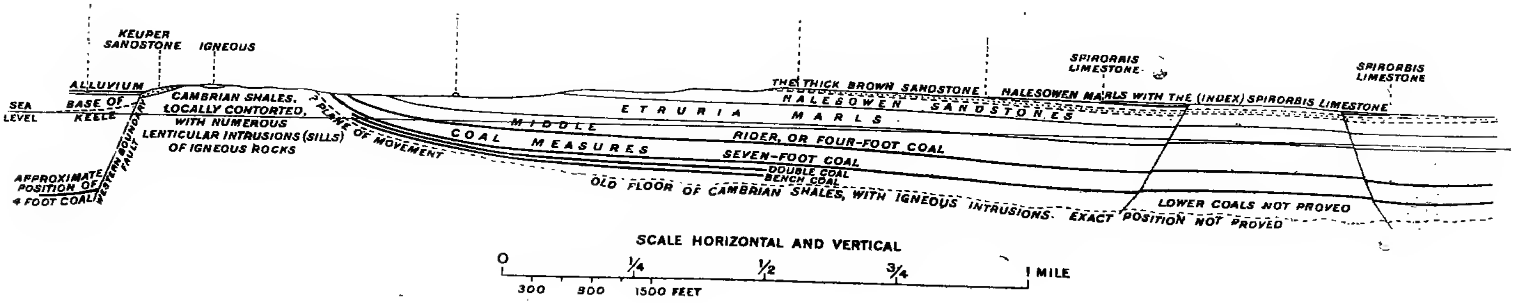
For some distance to the north and on the western sides of Dosthill, nothing is known of the Carboniferous Rocks or of the effect of the fault on them; but on the eastern side the belt of steeply-dipping beds continues northward for a considerable distance before turning inward to the coalfield and dying away in a belt of faulted ground between Wilnecote and Glascote. The nature of the junction of the Carboniferous and Cambrian on the east side of Dosthill is not known. Apparently no part of the Carboniferous is missing, but there may be a fault, and, if so, it must be more of the nature of an overthrust than a normal fracture.

The post-Triassic effects of the fault are shown on the west of Dosthill, where Keuper Sandstone clings to the hill-face (p. 148), while the Keuper Marls are faulted down at the foot of the hill. The throw cannot be less than 150 ft. and may be considerably more; it is, however, far less than in the underlying Carboniferous rocks, which have been affected also by pre-Triassic movements.

On the south side of Fazeley Bridge Carboniferous rocks occur on both sides of the fault. Those on the eastern or upthrow-side are known to be about the horizon of the Bench Coal, or, as shown on the Old Series Map, slightly below it. On the western side calcareous sandstone lying below the Spirorbis-limestone in the Keele group is thrown in, the total displacement thus amounting to the sum of the thicknesses of the productive measures above the Bench Coal (500 ft.) added to the Etruria Marl (200 ft.), the Halesowen Group (350 ft.) and some 50 ft. of Keele Beds, a total of 1,100 ft. This figure may be taken as the effective throw, for if there is any belt of sharp uprise towards the fault on the upthrow-side it must be narrow and its diminution of the effective throw will be at least counteracted by a steep dip down in the Keele Beds on the opposite side of the fault. At Fazeley Bridge the main fault gives off two branches, one on each side. The westerly branch lies hidden beneath the alluvial deposits; but in this neighbourhood it brings either the Keele Beds or a tapering edge of Keuper Sandstone against Keuper Marls at least 100 ft. above their base. Its position is indicated on the west side of the Tame, at the foot of the bridge carrying the canal, by a powerful spring. Farther north this fault must intervene between the Keuper Sandstone and the Keuper Marl, for there is not room for the lowest beds of the marls and the top of the sandstone to crop out naturally. The fault then enters an area of Keuper Marl, where it cannot be traced.

The eastern branch turns off in a north-easterly direction, entering the proved coalfield, where it formed the limit to the workings in the old Park Mines and is believed to have a throw, down north-west, of about 100 ft. Its farther course towards the Glascote road has been already described (p. 39). It splits up into a western portion, which has a downthrow of 36 ft. and rejoins the main Boundary Fault, and an eastern portion which continues in its former direction with a throw of 105 ft. for a

FIG. 5.—*Section across Dosthill and the Western Margin of the North Warwickshire Coalfield.*


KEUPER SANDSTONE
IGNEOUS
ALLUVIUM
SEA LEVEL
BASE OF KEELE
CAMBRIAN SHALES, LOCALLY CONTORTED, WITH NUMEROUS LENTICULAR INTRUSIONS (SILLS) OF IGNEOUS ROCKS
APPROXIMATE POSITION OF 4 FOOT COAL
WESTERN BOUNDARY FAULT
? PLANE OF MOVEMENT
THE THICK BROWN SANDSTONE
HALESOWEN MARLS WITH THE (INDEX) SPIRORBIS LIMESTONE
SPIRORBIS LIMESTONE
SPIRORBIS LIMESTONE
ETRURIA MARLS
HALESOWEN SANDSTONES
MIDDLE COAL MEASURES
RIDER, OR FOUR-FOOT COAL
SEVEN-FOOT COAL
DOUBLE COAL
BENCH COAL
OLD FLOOR OF CAMBRIAN SHALES, WITH IGNEOUS INTRUSIONS. EXACT POSITION NOT PROVED
LOWER COALS NOT PROVED
SCALE HORIZONTAL AND VERTICAL
0
¼
½
¾
1 MILE
300
900
1500 FEET

short distance, but farther on rapidly increases, as described on p. 39. On the north side of the Anker valley the Spirorbis-limestone which lies about 140 ft. up in the Keele Group crops out, and the depth to the Seven Feet Coal must be at least 1,100 ft. The effective throw of this fault has been proved in a level driven across it from the Seven Feet Coal at a point about 400 yards south of the Decoy Plantation. This trial, the details of which have been kindly supplied by Mr. F. A. Grayston, showed that on the upthrow-side the Seven Feet Coal has a low dip till almost in contact with the fault; on the downthrow-side grey measures were found in a nearly vertical position, but rapidly becoming less highly inclined as the level was continued. The basal band of the red Etruria Marl then descended into the level, and as this bed lies 480 ft. above the Seven Feet Coal in the Amington shaft, the effective throw could be calculated.

An estimate of the throw of the main Boundary Fault has been rendered possible by the recognition of Keele Beds on the downthrow-side at Fazeley Bridge. A little north of a row of cottages near the bridge the Spirorbis-limestone outcrops, with the overlying pellet-sandstone to the west of it in the canal-bank, all dipping in a westerly direction, that is away from the fault. On the upthrow-side the Seven Feet Coal was worked at a depth generally believed to be about 100 ft., so that the throw here must be somewhat more than 900 ft., which in this case is the effective throw, as there is no belt of sharply-rising rocks on the upthrow-side.

Between Fazeley Bridge and Glascote Road there is little change in the throw of the fault. On the downthrow side, though the outcrop of the Spirorbis-limestone ends against the fault, the overlying pellet-sandstone keeps at the surface to Kettlebrook and lies at a small depth for some distance to the north-east. Similarly, on the upthrow-side, there is no great increase in depth to the Seven Feet Coal.

A little north of Glascote a rapid diminution takes place. On the downthrow-side the Keele Beds strike parallel to the fault or keep at much the same horizon close to it, but on the upthrow-side the beds strike at right angles to the fault or approximately so. In consequence higher and higher beds come on, and near the Anker, where the top of the Halesowen Sandstones occurs on the upthrow-side, the displacement cannot be much more than 400 ft. Beyond this there is little or no further diminution. From this point onwards the Carboniferous rocks are covered by the Trias, and only the later movement along the fault can be estimated. As the base of the Keuper Sandstone is on the upthrow side at Shuttington House, near Statfold, and the top of this sandstone is some way down the hill to the south-west toward Amington Hall, the post-Triassic throw must be upwards of 200 ft. The fault may continue northwards in the Keuper Marl, but it cannot be traced. It is possible, also, that the Western Boundary Fault of the Warwickshire Coalfield is a continuation of the Western Boundary Fault (the Coton Park Fault) of the Leicestershire Coalfield (Sheet 155).

THE EASTERN BOUNDARY FAULT.

From a point a little south of the Watling Street, as far north as Polesworth, this fault throws Triassic rocks against Coal Measures, and its throw, therefore, cannot be measured. North of Polesworth, however, Carboniferous rocks occur on both sides. The rocks on the eastern side, westward of Warton (Sheet 155), are mainly of Keele age, but close to the intersection of the Main and the Warton Faults a small anticline brings to the surface the top of the Halesowen Group. The depth to the Seven Feet Coal may thus be estimated approximately as the depth at Amington shaft added to the thickness of the Halesowen Group, or at least 1,000 ft. in all. The depth to the same seam on the upthrow-side is approximately 200 ft., and the effective throw of the fault is therefore about 800 ft. In the case of the Warton Fault the post-Triassic effects only are visible at the surface, and what they amount to is indicated by a well and boring. The latter, put down a little south of Warton (p. 282), proved that the Bunter conglomerate is fully 236 ft. thick, while a well a little north of Warton penetrated 100 ft. of Keuper Sandstone (Waterstones) without reaching its base. A little N.W. of Warton the fault brings the base of the Bunter against the highest part of the Keuper Sandstone, and the post-Triassic throw alone must be at least as much as the boring and shaft added together, *i.e.*, 336 ft. The pre-Triassic throw is unknown. Where the fault enters the map, described in this Memoir, its throw in the Carboniferous rocks must be at least 1,000 ft. or more if the Warton branch has a pre-Triassic throw, as is almost certainly the case, but when it meets the inner Western Fault, which has a throw of 480 ft. where last proved (p. 160), its throw must be correspondingly diminished. A little further north a clue to the post-Triassic throw is given by the fact that a minute patch of Keuper Sandstone resting on the Keele Beds is faulted against the lowest beds of the Keuper Marl, indicating a throw of at least 100 ft. and possibly much more. The Spirorbis-limestone here crops out, so that the Seven Feet Coal must lie at a depth of about 1,100 ft. on the upthrow-side. Further north, at Statfold, the base of the Keuper Sandstone is thrown against the beds some way up in the marls and the post-Triassic throw must be somewhere about 200-250 ft. The post-Triassic throw of the Eastern Fault almost certainly ends at its meeting with the Western Fault, and its pre-Triassic throw may do so also.

SOUTH STAFFORDSHIRE COALFIELD.

THE EASTERN BOUNDARY FAULT.

By T. C. Cantrill.

At Rugeley, in Sheet 140, a mile beyond the northern edge of the present map, the Eastern Boundary Fault passes between Hagley Hall and the corn-mill in the Sheepfair, and throws down the upper beds of the Lower Keuper Sandstone on the east against the Bunter Pebble-Beds on the west. Between Rugeley and Chetwynd's Coppice (Sheet 154) it is clearly marked between the Keuper Marls and the Pebble-Beds. The actual fracture is visible in the roadside 100 yards north of the Old Engine Pit (the pumping-pit) of the Brereton Colliery (situated at the extreme northern apex of the Coal Measure outcrop), where the road-bank shows yellow conglomerate and pebbly sandstone of the Pebble-Beds, dipping north at 10°, against which, on the east, is faulted some yellow, false-bedded, pebbly sandstone of the Lower Keuper Sandstone. The fault hades eastward at 35° from the vertical. South of this point the fault is easily traceable towards Castle Ring, with Coal Measures on the west and various members of the Trias on the east.

Underground, in the Deep Coal workings of the Brereton Colliery,[1] it has been touched at various points along a line that lies 35 to 90 yards east of, and parallel with, its surface-position. As related by Jukes, a heading from one of the coals at a depth of 460 ft. from the surface was driven eastward through the fault into 'hard gravel rock,' believed to be the Bunter Pebble-Beds. This was done, it is said, at a point about 70 yards east of the present Old Engine pumping-shafts. There is, however, some discrepancy between the various statements concerning this heading. Jukes, in the Memoir referred to above, says that the heading was driven from the 15th Coal,[2] which agrees with the information supplied at the colliery office by the late manager, Mr. E. G. Sutherland. On the Horizontal Section,[3] however, it is said to have been driven from the 13th [or Deep] Coal, which agrees more nearly with the depth of 460 ft. given by Jukes, seeing that in the Old Engine shaft the Yard or 10th Coal is 313 ft. deep, and that consequently the 13th or Deep Coal would be 98 to 130 ft. lower, or 411 to 443 ft. from the surface, whereas the 15th Coal would be about 546 ft. or 578 ft. from the surface.

The post-Triassic throw of the fault may be computed thus. On the upthrow (western) side the base of the Trias lies just above the top of the Old Engine shaft. On the downthrow (eastern) side, allowing 70 ft. for the thickness of the Lower Keuper Sandstone and 400 ft. for the Pebble-Beds, we should have a throw of 470 ft. or 157 yards. It appears, therefore, that the heading, mentioned by Jukes as being 460 ft. from the surface, got into the Pebble-Beds at a level not far above their base, and that if it had been driven from the 15th Coal, instead of from the 13th, it might have struck the beds, whatever these are, that underlie the Trias on the downthrow side of the fault.

What these beds really are we have now no means of ascertaining, though an old boring at Brereton, put down about 1863-4, after the publication of the second edition of the Memoir, throws some light on the problem. A complete record[4] of the section was obtained by Jukes, and the boring was alluded to by Wm. Molyneux[1] in his work on Burton-on-Trent, published about 1869. Jukes's MS. states that the boring was put down 'in the field immediately west of Brereton Church.' A small circular depression in the ground, 170 yards south-west of the church and within 20 yards to the north-west of the colliery incline, is still pointed out as the site. A 6-ft. shaft 50 ft. in depth was first sunk, and the rest done by boring, presumably by percussion. The following is an abstract:—

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[1] Jukes, *op. cit.*, ed. 1, 1853, pp. 235-7, 285-6; ed. 2, 1859, pp. 105-6, 173-4, 180.

[2] Ed. 1, p. 285; ed. 2, pp. 173, 180.

[3] Sheet 23, No. 1.

[4] Preserved in one of Jukes's MS. section-books in the Geological Survey Office.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
[*Drift*]—Sand, gravel, and red clay	21	6	21	6
[*Lower Keuper Sandstone*]—Red sand-rock ...	17	6	39	0
[*Pebble-Beds*]—Red and white gravel, sand-rock, and some red marl	367	0	406	0
[*Hopwas-Beds ?*]—Red and white sand and sand-rock, red and yellow marl; some 'blue' beds	95	0	501	0
[*Coal Measures*]—Fireclays, dark clods, white sand-rock and rock-binds, with eight 'black smuts' and five 'black clods'	479	0	980	0

Molyneux, basing his remarks on the section supplied to him by J. Dean, at that time manager of the Brereton Collieries, was of opinion that the "upper coal-measure clay and grits" are absent, and implies that the strata below the Hopwas Beds are 'productive' coal-measures. The 'black smuts' may possibly represent coal-seams, though neither coal nor ironstone is mentioned in the record.

In the northern part of the Brereton workings the general dip is south-south-east at 3 in. per yard, and as we have seen (p. 73) the Shallow Coal crops out against, and is cut off to the north by, the base of the Trias. The effect of this dip, combined with the rise of the Triassic floor, and the post-Triassic downthrow of 470 ft., would be not only to carry the Deep Coal that much deeper on the downthrow side of the fault, but also to bring in above that coal a number of higher coals. The smuts in the boring may represent these coals.

But the possibility of the fault being in part of pre-Triassic date must not be disregarded. In this case we should expect an unknown thickness of still higher measures to come in below the Trias; but there is certainly no evidence in the boring-record to suggest that such high beds as the red Etruria or Aldridge Marls, or any of the red Keele Beds, are present, and, though possible, it is not very likely that the beds below 501 ft. are referable to the Halesowen or Newcastle Sandstones: they are too thick and contain too many 'black smuts.'

Farther south, a heading from the Deep Coal workings of the Brick Kiln Pit has been driven through the fault at a point about midway between Beaudesert Hall and Castle Ring, and at a level of about 17 ft. below Ordnance Datum (730 ft. below the surface). The heading got into red marls, which, from specimens preserved by Colonel R. S. Williamson, appear to be Etruria Marls. Their presence here, and their presumed absence in the Brereton Church boring, 2 miles farther north, accords with what we know to be the case at Brownhills, still farther south, where they come to the surface. In this neighbourhood, say at Chestall, therefore, the Deep Coal would be at most 2,430 ft. deep, if the following figures are approximately correct:—

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[1] 'Burton-on-Trent: Its History, its Waters, and its Breweries,' 8vo, n.d. [? 1869], p 161.

	Ft.
Glacial drift	50
Keuper Marls	100
Lower Keuper Sandstone	80
Bunter Pebble-Beds and Hopwas Beds ...	400
Etruria Marls, possibly	900
Productive measures above the Deep Coal ...	900
	2,430

If the heading referred to above entered the Etruria Marls near their top, the Deep Coal would have been thrown down 1,800 ft.; if it entered those marls near their base, the throw in the Deep Coal would be only 900 ft. But the throw in the Trias appears to be different. On the western side of the fault we see the base of the Bunter at Wandon and at Cannock Wood, so that the present surface of the Coal Measures at Castle Ring (800 ft. O.D.) is not far below the old Triassic floor. East of the fault, under Chestall (700 ft. O.D.), that floor lies 730 ft. lower. This then must be the post-Triassic throw. Of the total throw of the fault (1,800 or 900 ft.), 1,070 or 170 were effected before the Trias was deposited, and 730 ft. afterwards.

At Cannock Wood and Red Moor the surface-position of the fault is well-marked between the Coal Measures and basement-beds of the Trias on the west, and the Keuper Marls and Lower Keuper Sandstone on the east. A little south of Castle Ring the fault throws off a slightly divergent branch, with a small westward downthrow, which, after forming a shallow trough in the Triassic rocks, rejoins the main fault between Red Moor and Chase Terrace, near Cannock Chase No. 7 Plant, beyond which point the 'solid' rocks are concealed by Glacial drift. Here, however, the fault has been driven through from the Deep Coal at two points by headings which entered red measures, probably Etruria Marls, at a little below Ordnance Datum (p. 114). At Chase Terrace, a heading, alluded to on p. 175, was driven through the fault at a point situated 220 yards north-east of the upcast shaft of the Cannock Chase No. 5 Pits, and has been described and figured by Mr. A. Sopwith.[1] This exploration, which was carried eastward from the Deep Coal for a distance of 155 yards, was on a sufficiently large scale to show that the disturbance in the Coal Measures is of a highly complex character. Leaving the Deep Coal, in a nearly horizontal position and quite undisturbed, at a level of about 46 ft. above Ordnance Datum, the heading passed through a clean-cut fault into a belt of strata characterised by strong dips (50° to 70°), and by intense squeezing, compression, and shattering. In this belt were recognised, in their proper relative positions, first the Shallow

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[1] 'The Northern Part of the South Staffordshire Coal-Field,' *Trans. Fed. Inst. Min. Eng.*, vol. iii (1891-2 p. 50.

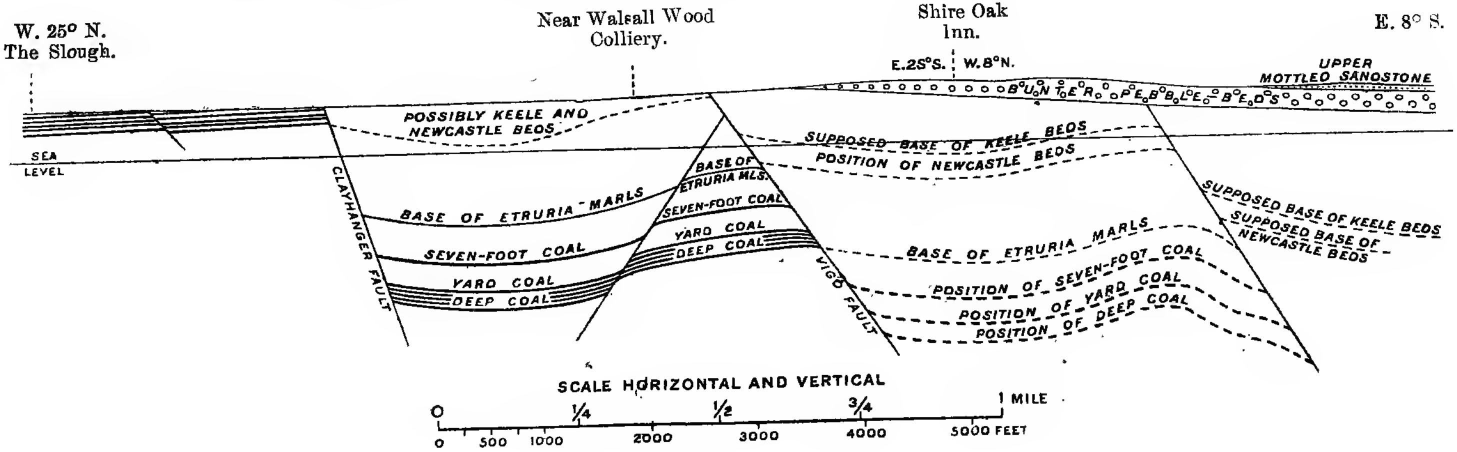
Coal, then the floor of the Bass, and then the Yard. Next followed a length of about 100 ft. of measures devoid of coals, beyond which succeeded a length of 55 ft. of measures containing six successive coal-bands, all swelling and thinning in a very unusual manner. These Mr. Sopwith identified with the seams known usually to lie 750 ft. above the Deep Coal. Beyond this group of coals the heading abruptly entered and continued for 190 ft. in a belt of red sandstones, marls and clays, all squeezed and jumbled, and dipping steeply eastward at 50° to 70°.

From these details the following points can be gathered: Firstly, the fault by which the Deep Coal is cut off is comparatively small, while the main fault must be that which introduces the red beds. What these beds are is uncertain; presumably they are either the Etruria Marls or the Keele Beds. From specimens preserved in the colliery office it looks as if they are Keele Beds, in which case the fault by which they are thrown down against the productive measures would be at least 1,200 ft. (300 ft. for the Halesowen Sandstones and perhaps 900 ft. for the Etruria Marls). Secondly, the measures between the recognizable faults are all intensely compressed and sheared out, and constitute a typical 'shatter-belt' at least 155 yards wide. How much of this disturbance was produced before the Trias was deposited cannot in this case be directly ascertained; but there is every ground for supposing that no such shattering affects the Trias at the surface. South of Chase Terrace the coals have been worked from the west up to the fault-line, along which the measures, shattered and highly inclined, plunge down to the east.

Somewhere near the Watling Street the fault splits into two branches. The western branch, which runs through Clayhanger, and is hence known as the Clayhanger Fault, passes through Shelfield and then curves south-eastward near Daw End to Pool Green, near Aldridge. The eastern branch, at first concealed by the Trias, runs under Brownhills, Shire Oak, and Vigo, and rejoins the Clayhanger Fault at Pool Green. This eastern branch is sometimes spoken of as the Aldridge Fault; but this name would be more appropriate for the fault that runs through the village of Aldridge and forms the western boundary of the Trias, and we shall therefore speak of the eastern branch of the boundary-fault as the Vigo Fault.

The surface-position of the Clayhanger Fault south of the Watling Street appears to be nearly identical with its underground position as proved in the old workings of the Shallow and Deep Coals under the Glacial drift of Brownhills Common. South of Wolverhampton Lane its position is uncertain. An eastward downthrow in the Shallow Coal has been touched in the Walsall Wood workings 100 yards west of the bridge by which the Midland Railway crosses Bridge Street, Clayhanger. If this is the Clayhanger Fault, it has a large hade from the vertical, for its surface-position appears to lie about 350 yards farther west. Red clay in the soil on Brownhills Sewage-Farm suggests that the surface-position of the fault touches the head of Ford Brook and keeps west of Grange Farm, where red clays have been worked for bricks; but south of this locality the ground

Fig. 6.—*Diagrammatic Section across the Eastern Margin of the South Staffordshire Coalfield.*



is thickly covered with Glacial drift, and it is not till we reach Daw End that the solid rocks emerge and enable us to locate it. Here it cuts off the various subdivisions of the Silurian rocks in succession (p. 16), and throws against them a narrow strip of the uppermost productive measures (p. 97). It can be seen in the Midland Railway at a point 76 yards west of the bridge that carries the road leading from Stubber's Green to Pool Green. The Wenlock Shales, with occasional thin bands of limestone full of fossils, and dipping westward at a low angle, are visible in the ditch on the northern side of the line. A few yards east of milepost 45¼, these beds flatten and turn down eastward, and at 16 yards from the milepost, and 76 yards west of the road-bridge, they are pugged up against red marls. These red beds are presumably Etruria Marls, separated by a southerly downthrow from the productive measures proved at the adjacent Victoria Colliery (p. 98). This branch fault probably follows the railway eastward as far as Aldridge Station and there falls into the Vigo Fault; the main fault—the one seen in the railway—runs south-eastward and joins the Vigo Fault south of Pool Green.

We have now to trace the course of the Vigo Fault from the Watling Street southward. A long and deep cutting on the L. & N. W. Railway between New Town and Brownhills Station exposes the Bunter Pebble-Beds, which dip gently to the east-north-east. How far they extend south-westward is uncertain, but their base probably reaches the surface, under the drift, along Brownhills High Street. From beneath them red marl emerges at Clayhanger and Shire Oak, but how much of this is referable to the Etruria Marls, and how much to the Keele Beds, cannot be determined owing to the paucity of exposures. Underground, however, light has been thrown on the problem by some explorations conducted by the Walsall Wood Colliery Co. and concluded in 1911. In an eastward direction the coals have everywhere been found to retain their normal thickness and gentle dips up to an irregular north-and-south line, beyond which they plunge steeply downward to the east. As already related of the Cannock Chase district (p. 164), the downfold is accompanied by intense squeezing, compression and faulting, the disturbed strata forming a shatter-belt of considerable width.

In the Walsall Wood Colliery's workings and explorations the most northerly point to which the downfold has yet been traced is situated 250 yards east-south-east of Ogley Hay church, where the Shallow Coal lies at a depth of about 2,115 ft. below the pit-top. From the Shallow Coal at this point a level heading (No. 23) was driven for about 600 yards in a direction bearing E. 10° N. For the first 75 yards the heading passed through fireclay and sandy shales in which a coal believed to be the Yard was represented by several broken and disconnected masses. From 75 yards to 148 yards the measures traversed consisted of fireclay, sandstone, shale and peldon, with a number of unrecognized coals, the whole series being grey in colour, and much squeezed and compressed, and dipping about E.N.E. at 15¾ in. per yard (24°). This series probably represents the upper part of the productive measures. From

148 yards the heading traversed a series of red and mottled marls, with occasional sandstones; at 270 and 308 yards bands of white and of purplish-red espley rock were found, which leaves little doubt that this series is referable to the Etruria Marls. Between 148 and 250 yards these beds are much disturbed and faulted; but beyond 250 yards they become more regular, and dip at 26°. Somewhere about 350 yards from its commencement the heading presumably passed through a fault and entered the Keele Beds, though the position and nature of the assumed fault were not determinable. That a fault or series of faults was passed through seems inevitable, for the remaining part of the heading showed nothing that could be identified as Halesowen Sandstones, but continued through a series of red and mottled marls, shales, and sandstones, up to the end at 596 yards. Though this series was found to be indistinguishable as a whole from the beds assigned to the Etruria Marls, certain peculiarities, such as the calcareous nature of some of the sandstones, and the occurrence of a purplish lavender-coloured sandstone at 510 yards, suggested that it belongs to the Keele Beds. The heading ended at 596 yards in red marls, which contained traces of a plant resembling *Cordaites*, and dipped E. 30° N. at 16°.

It appears, therefore, that the disturbance consists of a shatter-belt, about 250 yards wide, in which the strata are sheared, faulted, and greatly compressed, and dip more or less eastward at a gradually diminishing angle; that after leaving the Shallow Coal the upper part of the productive measures was traversed and was followed by the Etruria Marls; that the Halesowen Sandstones are either unrecognisable or are faulted out, and that the next subdivision encountered was the Keele Beds.

If this interpretation of the section is correct, it follows that a shaft sunk at the extremity of the heading (which is vertically under a point 250 yards E. 10° N. of the canal at Brownhills Mill) would probably prove the following succession:—

	Ft.
Keele Beds.—Red marls and sandstones, at least 250 ft., possibly much more; say ...	250
Halesowen Sandstones.—Grey sandstones and shales, with two or three thin and worthless coals	300
Etruria Marls.—Dark-red marls with pebbly beds or espley rocks (the red clays of Aldridge tileries)	400
Grey Productive Measures to the Shallow Coal, say	900
	1,850

As such a shaft would commence at a depth of about 2,060 ft. below the ground-level, the depth from the surface to the Shallow Coal would be somewhere about 1,300 yards.

From the point at which this trial-heading left the Shallow Coal, the downfold has been traced southward under Catshill toward Shire Oak. There it appears to die out, and its effects are resumed by a parallel line of downfold, about 200 yards farther east, which, commencing under the Anchor Inn, curves slightly eastward as far as a point lying 300 yards west of the

Shire Oak Inn, where it also dies out. In this part of the downfold a trial-heading ('the 100-Head'), 90 yards south of the Anchor, was driven eastward from the Deep Coal for 26 yards through disturbed measures, dipping eastward at 45°, in which the Bass and the Yard coals were with some doubt recognized.

The disturbance recommences its southward course under the Walsall-Lichfield road, 200 yards south-west of the Shire Oak Inn, where the Deep Coal was found to be squeezed down to a thickness of 1 ft. 7 in.

At Holly Bank the downfold passes into the workings of the Aldridge Colliery, where again important explorations,[1] concluded in 1913, have been made. At a point lying 400 yards east of the five ways at Vigo a pair of trial-headings was driven from the Deep Coal, in a direction bearing E. 12° N., for 1,310 yards, ending a little south-west of Upper Stonnall. The headings left the Deep Coal at a depth of 450 yards (1,350 ft.) lower than the pit-top, and were given an inclination downward of 1 in 4. Immediately beyond the fault the headings entered very broken, squeezed and faulted measures, believed to represent the upper part of the productive measures. At about 515 yards a westerly downthrow was passed through, which introduced the Seven-Foot, the Four-Foot, the Five-Foot, and the Brooch coals, lying nearly horizontal and fairly regular. At 860 yards another westward downthrow, of 270 ft., was passed, which brought up the Yard Coal in an anticlinal form, followed at 1,050 yards by the Brooch, Five-Foot, Four-Foot, and Seven-Foot coals in succession and dipping steeply eastward. At 1,120 yards another westward downthrow brought up a broken piece of the Four-Foot and Five-Foot again, beyond which, at 1,187 yards, an eastward downthrow brought in some of the highest productive measures, dipping steeply eastward, followed at 1,230 yards by dark-red marls and clays of the Etruria Marls, in which the headings were stopped at a distance of 1,310 yards, and at a depth of 2,310 ft. below the level of the pit-top, or 2,270 ft. under the surface of the ground at Upper Stonnall. That the red marls in which the headings came to an end are Etruria Marls is proved by the occurrence of a typical greenish-white espley rock at 1,276 yards.

Allowing 900 ft. as the distance between the base of the Etruria Marls and the Shallow and Deep coals, these latter must be more than 900 ft. below the end of the headings, or 3,170 ft. underneath Upper Stonnall.

It appears, therefore, that in the Aldridge trial-headings the disturbance begins with a considerable eastward downthrow, beyond which the measures, broken and thrown up and down by faults and flexures, finally show signs of dipping eastward at a considerable angle. The width of this belt of disturbance is at least 1,200 yards.

South of the point where the trial-headings left the Deep Coal the boundary-fault has been traced in the coal southward as far as the north-eastern corner of Leigh's Wood, where its course in the Yard Coal swings to the south-south-west for 500 yards, beyond which, toward Pool Green, nothing appears to be known of it.

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[1] F. B. Clark, 'Description of the Headings driven from the Aldridge Collieries to prove the Mines over the Main Eastern Boundary Fault,' *Trans. Fed. Inst. Min. Eng.*, vol. xlvii, p. 92 (1914).

So far we have considered only the underground position of the Vigo Fault; we have now to discuss its surface-position. The Walsall Wood headings lie beneath the outcrop of the Bunter, but not a sign of any such disturbance has been detected in the Trias at the surface. Eastward downthrows in the heading, if affecting the Trias, would appear at the surface in a more westerly position, and, ranging northward, would intersect the cutting on the L. & N.W. Railway between Brownhills Station and New Town. But no such faults are present: the only fractures are two trifling westward downthrows, amounting to about 10 ft. So far as can be judged, the whole of the disturbances proved to affect the Coal Measures are therefore of pre-Triassic date. South of the base of the Trias, however, the disturbances must reach the surface of the red clays of Catshill and Clayhanger. A broken line has therefore been drawn upon the map to represent the surface-position of the western edge of the disturbed belt, and to serve as a boundary between the Etruria Marls on the west and the Keele Beds on the east. The line is purely hypothetical, as the surface-exposures are indefinite and scanty. South of the Walsall-Lichfield road a slight rise in the ground a little east of Salter's Lane presumably marks the surface-line of the fault and divides the Etruria Marls of Walsall Wood from the Keele Beds of Holly Bank. At Vigo this line is specially well-marked, and the absence of the Halesowen Sandstones is clear. It then crosses a brook at King's Hayes Farm (p. 119), and by the side of the Aldridge road throws out a strong spring. Eastward the Keele Beds are well exposed, and the high eastward dips seen in the old quarries about Castlebank Plantation (p. 118) are doubtless connected with the disturbances proved underground. West of the fault-line the Etruria Marls are well displayed in the Aldridge clay-pits (p. 115). Farther south, opposite Leigh's Wood Colliery, the fault must separate the Keele red clays and cornstone visible in an old clay-pit just east of the Midland Railway from the Etruria Marls proved at the same level in the colliery-shafts. Southward the fault-line is again hypothetical as far as Pool Green, where it rejoins the Clayhanger or Daw End Fault (p. 165).

South of Pool Green, though nothing is known of the behaviour of the fault underground, its surface-position is clearly defined. Along its western side various Silurian rocks occupy the surface, while on its eastern side a narrow strip of Coal Measures, believed to be the Halesowen Sandstones (p. 116), comes in, from which the Keele Beds dip away toward the east. South of Daisy Bank the fault splits into two branches and admits another strip of Halesowen Sandstones before passing into Sheet 168.

On comparing the Vigo Fault with the Clayhanger Fault, it appears that the former is wholly of pre-Triassic date; the latter is, in part, of post-Triassic date, though it had produced a considerable throw in pre-Triassic times.

THE WESTERN BOUNDARY FAULT.

By W. Gibson.

Within the compass of the map, the Trias on the west side of the coalfield is nowhere faulted against the Coal Measures, so that a Western Boundary Fault, in the sense of one suddenly bringing in rocks newer than the Coal Measures, may be said to be non-existent. What faulting occurs is restricted to the Carboniferous rocks. A comparison of the explorations at Aldridge Colliery with those of Holly Bank Colliery shows that the nature of the faulting on the eastern side of the coalfield differs markedly from that on the western side. In the west the faults, so far from being associated with great compression of the strata, behave as gliding planes along which the Coal Measures are depressed gradually. The strata between them maintain a general uniform inclination as far as the farthest large dislocation to the west. Beyond this they dip more gently, but remain quite normal so far as proved.

Publication of the information obtained by the explorations at Cannock Old Coppice Colliery and Littleton Colliery is for the present withheld by request of the proprietors.

THE HINTS FAULT.

By G. Barrow.

This fault is roughly parallel to the Western Boundary Fault of the Warwickshire Coalfield, but throws in the opposite direction, or to the south-east. It is almost certainly a pre-Triassic as well as a post-Triassic fault, but the later movement only can be estimated, as no Carboniferous rocks occur at the surface on the downthrow-side.

It seems to attain its greatest throw in the ground between Hints and Hopwas, where it produces one of the best marked physical features in the district. In this part of its course the post-Triassic throw can be roughly estimated by the fact that on the upthrow-side the base of the Bunter Conglomerate runs near the top of a bank, and about 200 ft. above its foot. At the foot of the bank, and on the other side of the fault, there are marls which, by their freedom from sandy bands, must be at least 200 ft. up in the Keuper Marl. The Keuper Sandstone may be about 200 ft. thick; the Bunter is about 100 ft. thick, probably rather more. Thus the total displacement of the base of the Bunter is the height of the bank (200 ft.), added to 200 ft. of marl, 200 ft. of Keuper Sandstone, and 100 ft. of Bunter, or in all 700 ft. The throw in the Carboniferous is likely to be more.

Before Hopwas village is reached a fault having the opposite throw joins the main dislocation, and appears to reduce its throw by more than 100 ft., the whole of the Hamstead Beds being cut out. Some distance farther north the fault splits into two, for in a bank above the alluvium, about a third of a mile south of Tamhorn Park Farm, a small scar formed of the lower part of the Keuper Sandstone (p. 145) is brought against the base of the Bunter, so that a fault must intervene, having a throw of not less than 100 ft. On its east side the Keuper Sandstone is in contact, under the alluvium, with the Keuper Marls, which are proved by two borings on the opposite side of the river to be at least 200 ft. thick; thus the aggregate displacement amounts to at least 300 ft. To the north of Tamhorn Park a fault with a throw in the opposite direction meets the two branches and may possibly cut them both out, as is suggested on the map; but the further course of the fault is hidden beneath river-deposits.

Returning to the Hints area, the throw of the main fault is again diminished by the intersection of one having a northerly downthrow. This is best seen at Hints village, where the base of the Bunter is thrown down from the top of the hill to or below the level of the stream, the displacement being nearly 200 ft. The post-Triassic displacement of the main fault can be estimated again at Brockhurst Plantation. The base of the Bunter is brought against a horizon in the Keuper Marl, which is about 100 ft. above their base. The amount of the throw is therefore 100 ft. of Keuper Marl added to the thickness of the Keuper and Bunter Sandstones, giving a total of about 400 ft.

MINOR FAULTS.

Near Armitage, in a group of four faults all throwing down east, two have been traced for some distance. The most westerly at first brings the Keuper Sandstone against the Bunter, and the throw cannot be estimated, but to the south, on both sides of Upper Longdon, it cuts out the whole of the Keuper Sandstone, and the throw must be a little over 200 feet. Still farther south its throw diminishes, and its course in the Keuper Marl is difficult to trace. The two central faults are small, but the fourth has a somewhat greater throw, though its amount is difficult to estimate. Near Canwell Gate the main fault splits into two. The northern branch throws the Keuper Sandstone against the Keuper Marls, and the total throw cannot be less than 200 ft.; the southern branch brings the Keuper Sandstone against the Marl, the throw being upwards of 100 ft. The branches unite again near Little Sutton, and the total throw must be at least 400 ft., as most of the Keuper Sandstone and the whole of the Bunter are cut out, in addition to a small part of the Breccia and probably some 50 ft. of Keuper Marl. Farther south-west the throw probably decreases, for a lower horizon in the Keuper Sandstone is brought against the Marl. At Four Oaks Park the main fault is joined by a fault trending nearly south, and seems itself to turn in this direction, so far as can be judged in ground covered with drift.

The Bunter inlier of Whittington Heath, on which the barracks stand, is surrounded by faults. In no case can the throw be as great as the total thickness of the sandstone (200 ft.), and there is reason to believe it may be considerably less. Two of the faults are probably continued to the Hints Fault; the one on the west apparently forms the continuation of the branch fault at Hints village already described, and the one on the south is the fault which intersects the Hints Fault to the north of Tamhorn House.

The fault passing through Hints village, just described, is one of a group of three, all throwing down west, and approximately parallel. The most westerly runs a little east of Shenstone, and is shown by the displacement of the top of the Bunter; the displacement cannot be more than 50 ft., and is probably less.

North-west of Weeford a fault, throwing down to the west, starts in the Keuper Sandstone, and appears to break into two branches which re-unite about the village. Here the throw is shown by the fact that the top of the Bunter is about on the level of the road on one side and at about stream-level on the other. As there is a northerly dip in the Bunter here the throw is not likely to be less than 50 ft. On the other side of the stream the base of the breccia-beds is brought against beds some little way up in the Bunter. Farther south the throw appears to decrease, for the base of the Breccia crops out on each side of the fault at points comparatively close together.

In the southern part of the area between the two coalfields the diverse characters of the strata have facilitated the recognition of faults. The long inlier of Hamstead Beds stretching from near Hilton, past Lower Stonnall and Little Aston, to the railway north of Four Oaks, is for the most part bounded by faults. Along much of the western side Carboniferous Rocks are thrown into conjunction with Keuper Sandstone, the whole of the Bunter and the Breccia being cut out, and the displacement being not less than 200 ft. At Bosses the fault seems to make a sharp bend to the S.W. and then to split into two branches. The south-westerly branch cannot have a great throw and its course is obscure, but the other branch striking off to the south-east must at first have much the same throw as farther north, but it swerves round and diminishes, throwing first the Breccia against the Bunter, and farther on having Bunter on both sides. The southern part of the western edge is for the most part natural, the Breccia being normally superimposed upon the Hamstead Beds. The eastern margin also is faulted in the northern part of the inlier; at first the Breccia and part only of the Bunter is cut out, but farther south, near Lower Stonnall, the whole of the Bunter is thrown out of sight, and the displacement must be at least 200 ft. Near Forge Mill the fault disappears under alluvium, but there is little doubt that it is a continuation of the Canwell Gate branch of the Hints Fault, for the Keuper Sandstone on the north side of the alluvium must be faulted down all along its outcrop.

Near the southern edge of the area there are three nearly parallel faults trending north and south, and all throwing down to the east. The most westerly is first recognisable a little north of Mere Green. Here it throws the Breccias against the Hamstead Beds, and the throw must be small. Farther south it brings the Keuper Sandstone, some distance above the base, against the Bunter, and the throw may be as much as 100 ft. The second fault, a mile east of the last, is of little consequence, and the third, still farther east, is best defined where it throws the Marl against the Keuper Sandstone, forming the small inlier near Ashfurlong Hall. The most northerly point at which it has been recognised is near Fox Hill House, at an old pit for pipe-works, which was carried to a depth of 40 ft. without reaching the sandstone. South of the sandstone-inlier it may be assumed to pass near an old marl-pit (Barn Farm on the six-inch map), where skerry-bands dip at the unusually high angle of 10°. In the area of Keuper Marl farther east no faults are traceable, and there is no reason to suspect the existence of any of importance.

EXTENSIONS OF THE COALFIELDS.

The cover of Trias by which the Carboniferous rocks are concealed may amount in places to over a thousand feet, and it is often impossible to arrive at any safe conclusions as to the presence of Coal Measures beneath it, in view of the fact that those strata are affected by powerful faults that either do not cut the Triassic rocks at all, or do so with a greatly diminished throw. A pre-Triassic fault wholly unsuspected at the surface may terminate a concealed coalfield. In the following notes the extensions suggested are those believed to be most likely on the assumption that the mode of occurrence of the Palæozoic rocks beneath the Trias will be on the same lines as in the areas where this cover has been removed by denudation.

In discussing the extension of the coals between the coalfields of South Staffordshire and Warwickshire, we may consider the area under the three heads:—(*a*) the eastern side; (*b*) the central area; (*c*) the western side.

(*a*) *The Eastern Side.*—Evidence has been given to show that along the downthrow-side of the Western Boundary Fault of the Warwickshire Coalfield, Keele Beds occur either at the surface or immediately beneath the Trias, and farther that between the southern edge of the map and Glascote, or even Amington, that position is occupied by beds a little below or above the Spirorbis-limestone, which lies about 140 ft. above the base of the Keele Group. In all cases the dip is away from the fault, at first steeply and farther away at a smaller angle.

To the north of the Anker, however, at Statfold, there is a considerable thickness of beds above the limestone on the upthrow-side of the fault, and presumably there must be higher beds (beneath the Trias) on the downthrow-side also. In other words, higher beds are coming on northwards towards the Leicester Coalfield.

The fault can be traced no farther, but it is probable that it is continuous with the Linton or Coton Park Fault of the Leicestershire Coalfield, which is regarded as 'not far from the western limit at which the coal-seams can be worked successfully.'[1]

It has been proved in the workings at Coton Park Colliery that on the upthrow-side of the fault the beds tend to keep at much the same level, but that on the downthrow-side they dip southwards, with the result that higher and higher beds come on in that direction. Thus the Main Coal had descended 705 ft. below its position at the bottom of the shaft, and was still dipping south when the workings were stopped. If continued, this dip must bring on the Keele Beds in continuation with those which lie on the downthrow-side of the Warwickshire Western Boundary Fault. Where this happens it is impossible to say, for the amount of pre-Triassic erosion undergone by the Keele Beds cannot be estimated, but it may be assumed that the Keele Beds terminate before the pre-Triassic hollow of Lullington (p. 155) is reached. This, however, does not preclude the possibility of the more deeply seated coal-seams continuing across from one field to the other. So far as regards Warwickshire the depth to the productive measures would seem to be calculable on the outcrops of Keele Beds west of the Boundary Fault near Tamworth. Farther south productive Coal Measures may be absent under the Trias.

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[1] The Geology of the Leicestershire and South Derbyshire Coalfield, *Mem. Geol. Survey*, 1907, p. 90.

(*b*) *The Central Area.*—That the westward dip observable near the Western Boundary Fault continues into the central area is shown by the fact that the Hamstead Beds are brought up by the Hints Fault. Again, one and a half miles from the South Staffordshire Coalfield, in the Streetly or Little Aston boring, the Hamstead Beds have been penetrated to a thickness of over 1,800 ft., and the Hamstead and Keele Beds together are believed to be at least 2,800 ft. thick. Northwards they have been proved by wells or borings to extend as far north as Lichfield, and there is no doubt that here also a high horizon was proved. How far north of Lichfield they extend it is impossible to say.

(*c*) *The Western Side.*—The Keele Beds, emerging from beneath Bunter Sandstone, extend to the Silurian area of Walsall, but near Barr Beacon the Hamstead Group is present. At Upper Stonnall an easterly dip prevails, and the beds of the long inlier farther east presumably belong to a high horizon.

Farther north again the long heading described on p. 168 ended in Keele Beds at a great depth below the surface, and proved that at this point the first workable coal is likely to lie at a depth of about 3,900 ft. below the surface.

Still farther north, at Chase Terrace, another heading, starting at a level of about 50 ft. above the sea, was driven across the fault and a belt of disturbed ground, finally reaching red marls and sandstones believed to be of Keele age. The coals here also must be at a great depth.

Nearly a mile to the north of Chase Terrace another trial-heading ended off in what was taken to be part of the Etruria Marls. The cover of Trias above the heading is too thick to allow of any Keele Beds being present (p. 164).

Another heading, midway between Castle Ring and Beaudesert Hall, also terminated in Etruria Marls, but probably at a lower horizon. Farther north nothing is known of the Carboniferous rocks beneath the Trias till Brereton is reached, where the boring described on p. 162 proved grey measures, believed to lie above the first workable coal-seam.

It must not, however, be assumed that the workable coals have the same extension and continuity as the Keele Beds, for to the south of a line drawn from the northern end of the Silurian inlier of Walsall to that of the Cambrian at Dosthill there is always a chance that the pre-Carboniferous rocks may project in the old floor and that the coals are absent. Further, the phenomena of the Hints fault suggest the possibility that its existence may be connected with an uprising ridge of the older rocks. Apart from this the great depth to the coals would have to be taken into account, and from this point of view trials are more likely to be successful in the area north of that in which the Keele beds are present. Water in the Bunter would have to be contended with, and in the eastern part of the ground, at Lullington for example, the greatest amount would be met probably at depths approaching 1,100 ft.

CHAPTER IX.

PLEISTOCENE AND RECENT.

GLACIAL DEPOSITS.

GENERAL ACCOUNT.

By G. Barrow.

Glacial deposits are present over much of the area; indeed ice-borne pebbles are to be found in all parts of it. It would appear therefore that the whole was at one time covered by the ice. The great majority of the pebbles have been derived from the Bunter Pebble-Beds.

The Glacial deposits may be grouped under the following heads in descending order of age:—

Gravels believed to be of Late-Glacial age.
Unbedded Gravelly Drift—a 'boulder-clay' composed of gravelly material.
Bedded Sands and Gravels.
Boulder-Clay.

The Unbedded Gravelly Drift is the most widely spread, and has been the source of almost all the scattered pebbles referred to above. Though in mode of formation it is a boulder-clay, it contains so large a proportion of the debris of the Bunter Pebble-Beds that it generally forms a gravelly soil. Still it always contains some clay and is apt to set hard as it dries, nor does its soil 'burn' to the same extent as that produced by the Bedded Sands. In the north-western part of the area, especially about Cannock Wood, it locally contains much more marl, and then assumes more of the normal character of boulder-clay, but these occurrences are sporadic.

Though absent from the high ground of Cannock Chase, glacial deposits circle round the foot of it, and rapidly increasing in thickness to the south, completely mask the solid formations except near Bloxwich. In this western part of the area the drifts attain their maximum development; over much of the coalfield their united thickness not uncommonly amounts to over 100 ft., and is seldom less than 20 ft. to 30 ft. They form a low table-land, the valleys being cut either in or through them.

Eastward of a line drawn through Aldridge and Brereton the Gravelly Drift begins to break up into smaller, more isolated and thinner sheets, the area about Lichfield being largely free from it.

The rising mass of Bunter that culminates in Barr Beacon is fairly free of the Gravelly Drift, as is also the similarly rising ground to the north-east about Canwell, Hints and Hopwas; but between them lies a belt of ground, stretching in a south-easterly direction from Hammerwich to Four Oaks, within which small sheets of this drift are numerous, and become thicker toward the south.

A considerable part of the Keuper Marl area between the Hints Fault and the River Tame is irregularly covered with the Unbedded Drift; it is always sandy and never thick, the average being not more than 10 ft.

The greater part of the Warwickshire Coalfield east of the Tame is free from any distinct deposit of drift, but no part is entirely devoid of pebbles derived from it. These vary greatly in abundance according to no obvious rule; at times they are widely scattered, at others they occur in quantities, as on the high ground about Wood End, in the south-eastern part of the area, where they are matted together at times to a depth of about a foot. Resting on the red Keele marl they simulate true boulder-clay, and have been taken for such, but cuttings for drains about the new Wood End shaft have made their mode of occurrence clear.

The Unbedded Gravelly Drift also occurs in the area north of the Anker and east of the Tame, but in some cases it seems to have been mixed up with the slightly older flint-bearing drift to be described in the sequel. Much of the area is free from any drift except the scattered Bunter pebbles; but along the eastern margin of the map patches of unbedded drift, often of considerable size, are fairly common. It is not always possible to say if these belong to the deposit now described, or are the marginal fragments of a drift that is more widespread in the area to the east and is believed to have had an eastern origin. Little more can be said than that they are largely composed of Bunter material; but all the drifts, except the oldest till, are of this composition.

In the north-eastern area, which extends a little beyond the limit of this map, glacial deposits are mainlv confined to the small tract of ground east of a line drawn from Lullington northward to Walton-on-Trent. They consist of an admixture of sand and gravel; clay is rare, and the soils of the glacial deposits are principally of a light nature. The most extensive deposit of drift in this part of the area begins about Coton in the Elms, and stretches northward past the village of Rosliston (in Sheet 140); at the south end sand predominates, but at the north gravel forms a large portion of the deposit, a pit showing 10 to 12 ft. of sand with fine gravel. The more gravelly portion forms a fairly well marked ridge, but farther south the ground formed by it is flatter. The pebbles are almost entirely derived from the Bunter, and similar pebbles are scattered over all the adjacent district, sometimes in great numbers to a depth of 2 or 3 ft., while in other localities, as in the district around Edingale, they are rare, but they are never altogether absent. Flints are rare, if they exist, in this north-eastern part of the area, though their occurrence is recorded in the ground immediately to the east. Though the dominant component of the Unbedded Drift is Bunter debris, far-travelled boulders occur also, and these have given rise to a considerable literature, the principal contributors[1] to which are D. Mackintosh (1880), Rev. P. B. Brodie (1881), W. J. Harrison (1882, 1895, 1897, 1898), Rev. W. H. Crosskey (1887),

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[1] *See* Bibliography, p. 284.

Rev. W. Tuckwell (1887), and H. G. Mantle (1897). These authors deal mainly with the northern and western part of the area, there being apparently few erratics in the ground farther to the south-east.

Over a considerable part of the South Staffordshire Coalfield far-travelled erratics have been found. Among the more common is grey granite from the south of Scotland; others have been derived from the Lake District and from North Wales, thus showing both a northern and a north-western origin for this drift. Specially noticeable are certain blocks of felsite, some of which are of great size, one measuring 9 by 6 by 3 ft.

Some of the small patches of drift about Lichfield have yielded Lower Lias fossils as boulders which must have travelled from the outlier at Abbots Bromley, in a direction somewhat east of south.

In the south-eastern part of the area, so far as is known, not a single erratic has been found except the Bunter pebbles. These often occur vertically embedded in the deposit, which rarely shows any trace of true bedding. The pebbles themselves are of special interest. Generally they have lost their original characteristic pitting, but in this area they have not always done so. Where the retention of this first begins to be well marked is not known, but that the pitting is more and more preserved as we proceed in a south-easterly direction towards Tamworth has been clearly established. The Keuper Marl area to the south-east of the Hints Fault is largely covered with unbedded drift, and in this the majority of the larger pebbles are practically as well pitted as those still included in the Bunter. Taken in connection with the absence of erratics, this fact suggests that the pebbles have not been carried far. Flints are distinctly rare in any part of the Unbedded Drift; they seem to be absent in the area where the pitting is best preserved.

The Bedded Sands and Gravels, as already mentioned, yield but few flints in the western part of the area under description, but in the eastern part contain a considerable number.

The western gravels, with few flints, like the unbedded drift, are composed of materials derived from a north-westerly source. They differ only in containing, in parts of the South Staffordshire Coalfield, fragments of Keuper sandstone, coal, and other local constituents. In the western part of the area they locally rise up from beneath the Unbedded Drift and form curved irregularities somewhat resembling esker-mounds. That they underlie the other drift can often be seen along the sides of the valleys, and though they form no large part of the surface of the coalfield, they must have a wide extension beneath the unbedded material.

Eastward of this they are rarely seen; good exposures occur near Four Oaks and near Hopwas.

The eastern gravels with flints, where typically developed, consist of well-bedded yellowish sand and gravel in which, with the usual Bunter pebbles, there are present also a noticeable number of flints. Some idea of the relative abundance of flints in the two drifts can be gained by the fact that in the area of the eastern drift an average of thirteen could be picked up without moving from one spot, while in that of the western drift it was difficult to find more than two or three, if any, in a large field. Other far-travelled rocks are scarce; Carboniferous chert is the most common among them. The flints have much the same colour as the sand in which they are embedded, or may be slightly browner; when weathered all possess a well-marked patina. In exposed positions both sand and flints are bleached nearly white to a depth of about a foot from the surface. The flints are of a fairly uniform size; few exceed 2 in. in length, and many are smaller. Their original surface is rarely preserved, but they show little sign of rounding, and are for the most part angular to subangular. A section across the long axis is often rudely triangular, and many approximate so closely in form to worked flints as to suggest that they may have been used as implements.

They never show signs of having been battered on a beach, and in this they differ from the few flints that occur in the western drifts, among which it is not uncommon to find one showing the rounding and the nodes of percussion distinctive of beach-pebbles.

The sands and gravels of eastern origin seem to have entered this area by way of the valleys of the Anker and the Mease, and to have spread into the adjacent low-lying valley of the Tame and of the Trent at its junction with the Tame. In the Anker valley the southern limit of the deposit is roughly coincident with the canal as far as the Amington road, after which it fringes the southern margin of the alluvial deposits as far as Kettlebrook. Flints are scattered on the hill-slopes bordering the south side of the valley but not over the hill-tops. Possibly the sands and gravel once filled the lower part of the valley, for the small detached hill of Royals, which is surrounded by the river-deposits of the Anker, is still completely covered by flint-bearing sand and gravel, as is also the north bank of the Anker about Warren Farm.

That the material was poured out in a fan-like form seems clear, for it does not occur on the west side of the Tame till Tamhorn is reached, nearly 3 miles north-west of Kettlebrook. After this the deposit forms considerable though rather thin spreads about Hademore and Thatchmore in the neighbourhood of Whittington, while still farther north-west it seems to merge into the high-level sand and gravel bordering the Trent about its junction with the Tame. Similar high-level gravels occur on the west bank of the Trent to the north of Alrewas (p. 192). Taken as a whole the drift of eastern origin does not rise to the same height as that of western origin; it seems to be absent from most of the higher ground bordering the Anker and the Mease.

A stiff, hard boulder-clay containing erratics in abundance was found in an excavation close to the fault at the north-east end of the Warwickshire Coalfield. Among the boulders were many angular blocks, some clearly of Charnian origin. The deposit is limited to a small patch at the bottom of a small hollow on the eastern edge of the map at Lat. 52° 39′ 12″, and forms the most westerly occurrence of an eastern till, the remains of which are abundantly strewn over the ground immediately to the east. There it is believed to be the oldest of the local Glacial deposits.[1] G. B.

LOCAL DETAILS.

THE BEDDED SANDS AND GRAVELS.

At Oldfallow, N.E. of Cannock, there is a pit in the stratified sands and gravels some 30 ft. deep. The lowest bed exposed is composed of large, well-rounded blocks of chocolate-coloured sandstone similar to that of the Keuper of Penkridge (Sheet 153). Above this come bedded sands with lenticles of gravel, the whole firmly cemented together and closely simulating Bunter Conglomerate. A few pockets of gravelly clay occur toward the top of the section, from which the quarrymen state that some erratics of grey granite, seen on the stone-heaps, were obtained. To the north the beds seem to end off abruptly against the Bunter; southward they give rise to a prominent mound extending to the northern outskirts of Cannock town.

The town itself stands on red gravelly clay. The bedded sands emerge further south, and are quarried near the Union Workhouse, St. Mary's School, and the railway-station. In places, as near the back of the chapel on the north side of the street leading from the station, the sands are cemented.

About a mile north of Bloxwich there are two mounds of gravelly sand, not yet opened up except to a limited extent near Fishley Colliery. A little to the north-east of the town gravels appear at the surface along a low ridge extending from Little Bloxwich to Blakenhall Heath. A pit to the west of Little Bloxwich 18 ft. deep shows fine gravel containing lenticles of sand with thin layers of laminated brown clay.

At North Walsall similar sands with clay-bands come out from beneath 10 ft. of contorted pebbly sandy clay in a large sand-pit east of the railway-station.

To the west of the town of Walsall these sands and gravels form the prominent ridge on which the reservoir of the South Staffordshire Waterworks stands; this detached mass may have been continuous with some occurrences on the eastern side of the town. To the south of the reservoir, near Park Farm, a quarry gives a section of 20 ft. of well-stratified sand and gravel.

About half a mile to the west these deposits form a prominent ridge fringing the alluvium of the north side of the Tame. In this a sandpit close to the junction of the two canals shows red pebbly clay from 8 to 10 ft. thick, resting on evenly-bedded sands containing lenticles of gravel; the latter are as usual mainly of Bunter pebbles, but there are also present many well-rounded fragments of coal. W. G.

East of North Walsall station the various railway-cuttings, 30 ft. or so deep, show nothing but signs of sand and gravel. A large pit 200 yards south-west of Ryecroft Farm showed (in 1911) the following sequence, in descending order:—

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[1] 'The Geology of the Country between Atherstone and Charnwood Forest,' *Mem. Geol. Survey*, 1900, p. 37.

	Ft.
Red sandy clay, stiff, pebbly	10
Yellow sand and gravel, bedded	6
Red clay, pebbly	4
Old workings, probably sand and gravel, with signs of buff sand and laminated silt, say...	10
	30

Some of the beds are contorted. The pebbles are chiefly derived from the Bunter, but a few Chalk flints also are present, one of which yielded Bryozoa, *Cidaris* spines and plates, and a brachiopod, *Kingena?*

Jukes[1] records the following section of the Drift over the Coal Measures at Ryecroft Colliery, which probably was on the site of the present cemetery:—

	Ft.	In.
Soil	1	0
Clay	3	0
Dry sand	38	6
Gravel and sand	6	0
Strong blue clay	1	0
Quicksand, full of water	27	6
	77	0

At the bottom of the 'dry sand' large boulders of basalt were found, with rolled pieces of coal and of ironstone. The sand at Ryecroft was formerly dug for moulding-sand; some of it was white, and was pure enough for glass-making.[2]

The Drift runs through Walsall, occupies the lower parts of the town, and ends off eastward in a long and lofty ridge of sand and gravel, on which the church and the old part of the town are situated. In the town there is an old sand-pit behind the houses on the eastern side of Ward Street, and red gravel and sand were exposed in 1911 in Lower Rushall Street. An old gravel-pit[3] stood on the south side of Birmingham Street at its junction with Ablewell Street, while another behind the Highgate Brewery was 12 ft. deep. The West Bromwich Street gravel and sand-pit (between Bath Road and the end of Thorpe Road) in 1911 showed (1) bedded red and brown sand and gravel, 25 ft. thick, over (2) reddish-brown sand, exposed for 5 ft., below which the sand is waterlogged and cannot be dug. The upper bed (1) consists of alternations of sand and gravel, 2 or 3 ft. of gravel to one of sand. The pebbles are nearly all Bunter, though the crush-marks are usually obliterated. Some few pebbles of coal occur. The generality of the pebbles are 1 or 2 in. long; a few range up to 9 in. The bedding dips northward at 10°.

On the southern end of the gravel-ridge a section in a pit on the golf-course, 500 yards west of Gorway House, contains an interesting assemblage of pebbles, and shows about 8 ft. of light-red sand alternating with thin seams, up to 3 in., of gravel. The beds dip S. 30° E. The pebbles are chiefly from the Bunter, but there are many of ironstone, and of sandstone with plant-remains from the Coal Measures, as well as some well-rounded pieces of Triassic sandstone and Chalk flints. A well-striated nodule of limestone, probably Silurian, was seen. The ironstone-nodules are so abundant on the floor of the pit as to make it likely that one of the lowest ironstone-bands (probably the Diamonds) of the Coal Measures crops out just below. T. C. C.

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[1] *Vert. Sect.*, Sheet 16, No. 7, and MS. Section-Book in Geol. Survey Office.

[2] Thomas Pearce, 'The History and Directory of Walsall,' 8vo, *Birm.*, 1813, p. 141.

[3] Snape's Map of Walsall, 1782.

Near Streetly the bedded sands and gravels are best exposed near the railway-station, where they reach a thickness of nearly 30 ft. They consist of alternating layers of sharply angular sand and fine gravel, the former being of an extremely bright colour. The gravel-bands are lenticular and the pebbles are of Bunter derivation, but have been broken into angular fragments. Their average size is so much less than is the case in the Unbedded Drift as to help in the distinction of the two drifts. C. H. C.

To the east and north-east of Little Aston the bedded sands and gravels belonging to the western drifts are absent, or perhaps locally represented by a few minute patches or pockets of white sand that underlie the unbedded material to the west of Drayton Bassett.

In the Warwickshire coalfield area they are entirely absent, but north-westward of Tamworth a mass of considerable size lies strangely isolated at the foot of the Bunter escarpment immediately north of Hopwas. The gravels are banked against a steep rock-slope, and extend northward for about a quarter of a mile. Though much has been dug there is still much left opposite the old school at the north end of the village, and in this is situated the Hopwas gravel-pit already referred to (p. 124).

The gravels have been deposited over the edge and round the apex of a slipped rock-mass, the rock-floor being consequently very uneven. Behind the apex and in the inner part of the pit the gravels are nearly horizontal, but in the outer pit they dip steeply eastwards towards the canal, and are banked against a steep rock-face. The deposit consists of fairly fine sand, well-bedded, and containing a number of lenticular beds of gravel. The latter so far as could be seen are composed exclusively of Bunter pebbles, and when cemented simulate Bunter Pebble-Beds. The pebbles are, however, on the whole smaller, have lost their perfect rounding and all traces of pitting, and are often broken. Not a single flint has been found in this pit, but only half a mile to the north, at the north-east corner of the wood, they appear suddenly in considerable numbers at the margin of the area of the eastern drift. G. B.

THE UNBEDDED GRAVELLY DRIFT.

Over most of the western part of the South Staffordshire Coalfield there is spread a deposit of sandy gravel mixed with red clay without any definite arrangement; the bulk of the pebbles in it are of Bunter origin, though in this district erratics are often present as well; this unbedded drift generally rests directly on the more solid formations, but in a few rare cases it is underlain by the bedded drift described above. Of small economic value, the unbedded drifts are seldom seen in section, and are exposed only when they form the overburden of the more valuable materials beneath them.

At Bridgtown, in an excavation in the Etruria Marls for the Longhouse Tileries, the south-eastern side showed a hollow in the marls filled in with stiff red clay, about 9 ft. thick, containing numerous erratics and two lenticular bands of coarse gravel.

Further south, at the Essington Tileries south of Cheslyn Hay, another irregular hollow in these marls is occupied by about 10 ft. of red sandy clay with foreign boulders, the latter near the base consisting of large blocks of grey sandstone, one weighing between 3 and 4 tons. Elsewhere the sections are of little consequence, of limited depth, and seldom revealing the underlying rock. In the records of shaft-sections the drifts are usually described as so much 'clay and sand,' without specifying how much of this is sand and how much clay. A thickness of drift amounting to 50 ft. is not uncommon, and generally within the drift-covered areas the shafts record from 15 to 20 ft. of sand and clay.

The sandy red clays, as at the Longhouse Tileries, contain erratics. These are commonly more or less rounded blocks of grey granite and felsitic rocks. If it may be assumed that the clayey drift extended across the entire district, excepting possibly the Chase, it is not surprising to find the country still strewn with erratics. They are absent from the higher part of Cannock Chase, but occur sparingly along its western flanks, and are abundant to the east and west of Cannock. Blocks of a grey granite, showing all the characters of the Dalbeattie granite of the south of Scotland, are particularly abundant around Cannock and to the east, suggesting indeed a local stranding of such erratics. But the most universally distributed are blocks of a felsitic rock (the so-called 'felsites'), some of which are of large size. One measuring 9 by 6 by 3 ft. occurs in a field on the west side of the L. & N.W. Railway, 750 yards south of Great Wyrley Colliery. Blocks traceable to a derivation from the Lake District, which are so widely scattered over the North Staffordshire Coalfield, have not been met with south of Huntington in the south part of Cannock Chase, though they are not uncommon to the west of Wolverhampton (Sheet 153), and occur sparingly on the western flanks of Cannock Chase to the north of Huntington. Pebbles of flint are rare or absent in this part of the district. W. G.

West of Brereton what appears to be Glacial Drift forms patches in the Rising Brook Valley near Smart's Buildings. A small mound at the Keeper's Lodge in the same valley a mile farther to the south-west may be of Glacial origin.

At Rugeley Town station (Sheet 140) a small patch of similar sandy gravel, no doubt in this case of Glacial origin, overlies the Keuper Marls. Around Brereton a larger spread of similar material extends upward from the Trent alluvium to the foot of the Bunter fault-scarp, covers much of the outcrop of the Lower Keuper Sandstone, and spreads onto that of the Keuper Marl, producing everywhere a stony light soil. It is probably nowhere thick, as some of the graves at Brereton Church are said to reach sand-rock (Keuper), while in the adjacent allotment-ground to the north-west a band of marl in the Keuper has been worked for bricks by digging through the gravelly subsoil. Farther south the drift runs in a tongue along the bottom of the valley east of the Springs, and forms an outlier on the higher ground west of the valley.

In Beaudesert Park, and thence along an irregular line ranging south-westward toward Hednesford and Cannock, the drift comes on in force, and spreads over the Trias and Coal Measure outcrops nearly as far as Walsall. It has, however, been deeply trenched by post-Glacial erosion, so that while drift covers most of the higher ground, the 'solid' rocks are exposed in the valleys.

At Chestall, red clayey gravel full of Bunter pebbles was proved in 1910 to a thickness of 15 ft., and then not bottomed, at a new reservoir 150 yards north-west of the house. In the Gorse Covert, 200 yards south-south-west of Chestall, it was proved in a bore-hole for water to be 64 ft. thick. It is displayed in the ramparts and ditches of Castle Ring, where it caps the highest ground (801 ft. above O.D.) in the district, and a well just outside the south-eastern angle of the camp failed to reach 'solid' rock at 25 ft. Many of the cottage-wells at Gentleshaw do not appear to have got through the drift even at a depth of 60 ft. On Gentleshaw Common, 400 yards south-south-west of Brook Farm, gravel with salmon-red marly matrix is dug for road-stone to a depth of 10 ft.; the uppermost 2 ft. show the usual bleaching. But the best section in this locality is that afforded by a large gravel-pit, in the valley south of Gentleshaw Hill, in which gravel is exposed to a depth of 24 ft., while a few yards to the east the Keuper Sandstone has been quarried at about the same level. The gravel must consequently fill a steep-sided pocket or channel.

West of this point the edge of the drift turns south-westward towards the high ground about Cooper's Lodge (784 ft.), though several small outliers show that it once extended farther north. Around the clay-pit at Cannock Chase No. 7 Plant it is 10 ft. thick, and rests on the Coal Measures. Clay, sand, and gravel, 38 ft. thick, were sunk through at No. 8 Plant, north-east of Five Ways.

South of Cooper's Lodge the surface of the country steadily declines southward as a featureless plain completely covered with a sheet of gravelly boulder-clay, composed chiefly of Bunter materials, which is nowhere cut through by natural sections or open excavations. In the shafts of the Coppice Colliery, at Five Ways, gravel and red and blue stony clay, 56 ft. thick, cover the Coal Measures, and the drift was not bottomed in the railway-cuttings a mile farther south. Between Five Ways and Norton Canes the gravelly Bunter drift gives place to a more clayey type, which contains a smaller proportion of Bunter pebbles and a large admixture of subangular pebbles of felsites, slates, etc., presumably of Welsh origin. This type of drift may be seen at a pond 300 yards north-west of Commonside Farm. In the same district large boulders of igneous rocks become frequent. North of Cannock Chase reservoir the shafts at Cannock Chase No. 3 Plant at Norton Bog proved 42 ft. of Bunter drift; those at No. 5 Plant at Chase Terrace proved 58 ft.

Eastward and southward of Chase Terrace the drift grows thin, and allows the 'solid' rocks to be seen in the lower ground. At Ball's Mount (p. 147) the drift is a dark-red loamy gravel, 12 ft. thick, and shows irregular and contorted bedding. A little farther south the drift comes to an edge round the margins of the low ground between Chasetown and Brownhills Common, though several small outliers on some of the higher points show that it once extended across the intermediate space. A section on the mineral-railway half-a-mile south-west of the Triangle is of interest as showing drift gravel filling up a narrow steep-sided channel eroded in the Bunter sandstone (p. 137). West of Chasetown the shafts of No. 2 Plant of the Cannock Chase Colliery proved the drift to be 26 ft. thick.

South-east of the reservoir the drift comes on again, maintaining its Bunter characters. A gravel-pit 100 yards south-west of St. Thomas's Church at Brownhills Common shows 8 ft. of gravelly red boulder-clay full of Bunter pebbles. No flints were seen. South-west of the reservoir both the Midland and the L. & N.W. mineral railways show nothing but red clayey gravel and red sand, chiefly of Bunter origin, but with an occasional Chalk flint. Farther west, however, about Norton Canes and Wyrley Common, and thence southward to Pelsall Wood, this gravelly type of drift merges into a stony and gravelly red boulder-clay; Chalk flints become more plentiful, and large igneous boulders are abundant on the surface. At Norton Canes the upcast shaft of the Conduit Colliery pierced 56 ft. of clay, sand, and gravel drift; at the Cathedral Pit, west of Brownhills Common, 45½ ft. of boulder-clay and sand were passed through; while in the No. 1 Shaft of the old Conduit Colliery on the Watling Street (at the 21st milepost from Newport) the drift, which consists of alternations of clay, sand, gravel, loam, and marl, proved to be 72 ft. thick.

Around Birch Coppice, west of Brownhills L. & N. W. Station, the drift thins away and the Coal Measures are exposed. The valley south-west of Pelsall has cut through the drift into the Coal Measures. On the north side of the valley the Pelsall Hall No. 2 Shaft, 100 yards south of the Hall, proved that the sand and gravel are only 16½ ft. thick. A little farther south-east, however, the drift descends to the stream, and a railway-cutting at Heath End shows nothing but gravel and sand. In the valley at Coal Pool the Coal Measures are very near the surface, though the workings in the Bottom Coal were stopped on the west and south by getting into a deep pocket of sand. An old roadside gravel-pit midway between Rushall and Daw End shows 15 ft. of irregularly-bedded red sandy gravel of Bunter origin.

Between Walsall Wood and Aldridge the drift forms two outliers. In the northern one a good view of the drift is afforded by the large marl-hole at Messrs. Joberns's tileries, where 4 to 11 ft. of red gravelly boulder-clay overlies the Etruria Marls (p. 116). The matrix of the boulder-clay is a stiff red clay, bleached yellow in the upper part; some beds are more gravelly and sandy than the rest, and some are contorted. The pebbles are almost wholly derived from the Bunter, but a few lumps of ironstone from the Coal Measures, as well as Chalk flints, are present. Some of the pebbles stand on end. In the southern outlier some sections are exposed on the railway a little west of Aldridge Station. T. C. C.

Near Lichfield much of the ground is free of drift though scattered over with Bunter pebbles; the more important occurrences are shown on the map. Though a small portion of clay is generally present the deposit forms a light gravelly soil. Erratics are not common, and they decrease in number from the west and north-west, till they cease a little S.E. of Lichfield. At that town a fragment of granite was found. **E. E. L. D.**

Further south about Shenstone and Little Aston the unbedded gravelly drift occurs in large masses; near Shenstone it was formerly much worked, but there are few sections open now. Near Little Aston, in Roundabout Wood, a pit shows 9 ft. of this drift resting on 4 ft. of Bunter Conglomerate. The drift is composed of deep red sandy clay with broken and worn pebbles, nearly all of which have been derived from the Bunter. Large irregularly shaped masses of yellow sand are of common occurrence, and there is no sign of any arrangement throughout the mass. Between the Rosemary Hill Wood and Roundabout Wood, Streetly, the unbedded drift covers a large area, and between Aston Lane and Streetly Lane excavations have proved it to have an average thickness of 15 ft. At Four Oaks Common it is generally over 12 ft. thick. In both places it is a soft, yellowish, loamy sand with irregularly scattered Bunter pebbles and occasional clayey patches.

A large number of erratics collected in the neighbourhood of Lynn and Stonnall has been described by Mr. H. G. Mantle.[1] He found representatives of felsites, andesites, basalts, granites of both Criffel and Skiddaw type, Buttermere granophyre, and various tuffs, as well as rocks of local derivation, such as Coal Measure sandstone. Some of the boulders are of large size, one found south of Barr Beacon measuring 5 ft. in length. The eastern boundary of the area within which they occur runs from Shenstone to Watford Gap and east of Sutton Coldfield. C. H. C.

The large area of Keuper Marl lying between the west side of the Tame and the Hints Fault is in part covered by drift. Towards Little Aston and Canwell Gate the drift is more extensive on the higher ground, while to the east, at a lower level and nearer the Tame, it is present in smaller amount. The reverse is seen further north, for on the two sides of the brook near Hints there is no drift on the higher ground, while it is widely distributed to the west of Fazeley, mostly on the lower ground. It is, however, never thick, and all the streams cut to the base of it or below it. Along the Watling Street near Fazeley, sewers showed it to be often less than 6 ft., and rarely more than 10 ft. thick. The deposit consists as usual of Bunter pebbles set in a sandy matrix, even where it rests on marl, and it forms the main local source of water. As far south as Trickley Coppice the pitting in the larger pebbles is almost as well shown as pebbles still in situ in the Bunter. Erratics are absent over the greater part of this ground.

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[1] H. G. Mantle, on Glacial Boulders East of Cannock Chase, *Proc. Birm. Nat. Hist. and Phil. Soc.*, vol. x, 1897, pp. 33-72, with notes by W. S. Boulton, on the Microscopic Characters of some Rocks occurring as erratics in the Lichfield District, pp. 73-80.

The matrix of the drift rarely possesses the red colour so often seen in the western area; it is generally pale yellowish brown to yellowish when not superficially bleached. In a few cases a little red marl is mixed with the gravelly material quite at the base.

Of the few other permanent exposures the most instructive is a small outlying patch on the south side of the Watling Street, a little south of Bangley Farm. The material lies in a position which allows the rainfall to percolate through most of it, and in consequence consists chiefly of massed pebbles with little matrix left. Where any matrix is left many of the stones are vertical and there is no trace of bedding. The pebbles are all of Bunter origin and many are broken.

South-westwards a section at the Wheatmoor Brickworks, close to the cross-roads, shows Keuper Marl overlain by 4 to 5 ft. of drift, the lower part of which is sandy and the upper part more gravelly. The pebbles are often broken. Further eastward sand predominates, and near Middleton is occasionally worked; one pit shows 2 ft. of unbedded sandy clay with broken pebbles resting on clayey sand. T. E.

The North Warwickshire Coal Field, east of the Tame, is practically free of drift except in the ground bordering the Anker; but no part of it is free from the scattered Bunter pebbles that represent the remnant of the unbedded gravelly drift. On the highest ground in the south-eastern corner of the map the pebbles are almost matted together to form a pebble-layer some 2 to 3 in. thick. In a recent cut for a sewer under the main road near Wood End a more or less persistent layer of pebbles rested on the Keele Marl. The sifting out of the pebbles after the matrix has been washed away seems to be connected with the flatness of the ground and on the slopes, caused by the outcrop of sandstone-bands. The pebble-film is always absent. The matted pebbles continue a short distance into the area to the east, and were there regarded as representing an appreciable thickness of drift. The small patch shown on the adjacent map 155 has been continued into this area, but a trench recently dug in it shows that it is actually only a layer of pebbles. G. B.

THE EASTERN DRIFTS.

BEDDED SANDS AND GRAVEL.

The bedded drifts which are distinguished by the presence of flint-pebbles are best studied in the Anker valley, the lower part of which they seem to have filled. Slightly east of this area, at

Shuttington (Sheet 155), they rest on boulder-clay which contains Charnian boulders as described on p. 180. Their occurrence here at a high level has a bearing on the age of the doubtful gravels described on p. 190.

No Chalky Boulder Clay has been met with in this district, though it occurs further to the east and south-east. The flint-bearing gravels, as is often the case, have travelled further than the clays in which the parent Chalk is met with.

Few of the many old pits in these drifts give clear sections; the most easterly occurs at Amington, close to the canal, where this is first crossed by the Tamworth road. In this pit, in addition to the usual Bunter pebbles and flints, a few small fragments of igneous rock were found. There is another and better exposure in a pit on the north side of the road at the east end of Bolehall; this is about 6 ft. deep and shows the bedded character of the deposit, and also that sand preponderates over gravel. A third pit occurs close to the edge of the Alluvium of the Anker, just outside the Isolation Hospital, opposite Tamworth. The original sheet of sand and gravel has been cut up by denudation into isolated patches, the largest of which occur on the isolated hill of Royals, and on the north bank of the river at Warren Farm.

These flint-bearing deposits form a thin skin over much of the lower part of Tamworth, but a little to the north they seem to give way to unbedded drift. At the top of the hill near the workhouse, the latter contains a sprinkling of flints, suggesting that the flint-bearing material has been incorporated in the later drift of western origin. A similar sprinkling of flints occurs to the south of Statfold in what in other respects is normal western drifts. This also may be a mixed deposit.

Flint-bearing material seems to have travelled along by the valley of the Mease also, but the flints in it are less numerous than in the drift of the Anker Valley. Patches of it are shown on the map at Haunton, Harlaston and Edingale, and in them there are numerous old pits, as also in the neighbourhood of Elford.

South of Croxall a fairly large patch contains flints in greater abundance, but this may be a remnant of the Anker valley drift.

The most southerly point at which flint-bearing drift occurs on the west side of the Tame is near Tamhorn. Flints are fairly common, and the deposit thus strongly contrasts with the bedded sands and gravel, only a short distance to the south at Hopwas, in which they are entirely absent (p. 183).

The flint-bearing drift comes on in larger quantity about Hademore and Thatchmore, where it rises gently to a height of 15 to 30 ft. above the river-terrace, and forms elevated ground which dominates the country to the west. It assumes a terrace-like aspect that is better marked near the junction of the Trent and the Tame (p. 190). G. B.

DREIKANTER.

At Whittington Hurst, where the gravel is dug for road-metal, there is a rather exceptional type of deposit consisting of whitish-yellow sand and gravel 3 to 4 ft. thick, resting with an irregular surface on reddish sand with fewer pebbles which is seen to 4 ft. Throughout the sand-grains are rounded, in contrast to the angular grains of the bedded drifts, and in the upper part many of the pebbles are etched along the softer bands in a manner suggestive of wind-action. Some, too, show the sharply keeled edges characteristic of dreikanter. An æolian origin for the upper part of the deposit is therefore suggested, and the bed is perhaps analogous to that described by Mr. L. J. Wills[1] occurring near Bromsgrove. But on the other hand these stones may have been derived from the Keuper Sandstone in which similar dreikanter are known to occur, though their abundance does not favour such a hypothesis. Dreikanter have also been found over most of the ground between Tamworth and Edingale, but not in situ (pp. 143, 144). C. H. C.

Over much of the central area of Keuper Sandstone a number of dreikanter composed of quartz and quartzite have been found; some of these are in perfect preservation, and selected examples have been placed in the museum in Jermyn Street. The epoch at which they acquired their distinctive shape has not been determined. They seem to be restricted to the outcrop of this sandstone, and somewhat similar pebbles have been found in situ in it, but none of them so perfectly shaped as many of those found loose on the surface. The suggestion is that the latter may be of comparatively recent origin, and may have attained their shape during a dry period corresponding generally to that of the formation of the Loess.[2] E. E. L. D.

LATE GLACIAL GRAVELS.

Near the junction of the Trent and the Tame, on the western side of the latter, broad sheets of sand and gravel rise to a considerable height above the river and present a terrace-like aspect, especially along their upper margin; the bedding is fairly well-marked. Where first seen this deposit appeared to be a high river-terrace, but it may be regarded as being of late Glacial age for the following reasons. No trace of a similar high-level terrace gravel has been found to the south, higher up the Tame. Moreover, flints are abundant, even to the extent of 10 per cent. of the stones in parts of the deposit, but diminish rapidly in numbers up the Trent valley. In two cases, also, the gravel rises above the terrace-level, as, for example, at Hilliard's Cross, some three miles N.E. of Lichfield. It could not have been derived from the upper part of the Tame valley, for the flint-bearing drifts end a little further south at Tamhorn. It seems clear then that the material of which the gravel is formed was originally part of the eastern drift which filled the broad open valley at the junction of the two rivers, but has since been cut through by both rivers, and more or less redistributed by them. Everywhere the gravels slope on the whole steadily towards the river, the total fall being as much as 40 ft. in some cases and rarely less than 30 ft.

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[1] L. J. Wills, on the occurrences of Wind-worn Pebbles in High Level Gravels in Worcestershire, *Geol. Mag.*, 1910, pp. 299-302.

[2] In South Nottinghamshire, dreikanter have been found by Prof. H. H. Swinnerton (*Geol. Mag.*, 1914, p. 208), abundantly in certain Drifts, and to a much less extent in the Keuper basement-bed. More recently Mr. J. W. Jackson (*Proc. Manch. Lit. and Phil. Soc.*, vol. lxii, pt. 3, 1917-18), has described some similar pebbles from sand overlying Glacial Drift near Manchester, and others resting on boulder-clay underlying the Lower Forest Bed of the Cheshire coast. He concludes that they have been formed from Drift pebbles in early post-Glacial times.

That the Tame valley was blocked at this point is suggested also by a feature seen on the ground to the south-west of Tamworth, between Bonehill and Tamhorn. At a considerable height above the river there runs a faint terrace-like feature in the unbedded gravelly drift, below which the surface slopes down to the first terrace with singular smoothness. Possibly this feature marks the highest flood-point of the dammed-back river.

On the south side of the Trent, in the Fradley district, these gravels were cut open when the railway was made and have been dug in several pits. Some of these are disused and partly filled with water; one completely overgrown is shown on the map close to the Rykneld Street, a little east of Fradley; another a little to the south-east still shows gravel accompanied by a little sand; in both the base of the pit is clay, probably the weathered surface of the Keuper Marl. A pit is still being worked on the eastern side of the railway, about 400 yards south-west of Roddige; here the deposit consists mainly of gravel with a small amount of sandy matrix. In addition to the Bunter pebbles, of which the bulk of the gravel is always composed, there are present a fair number of fragments of granite and other igneous rocks as well as a considerable number of flints. Some of the pebbles are large, one perfectly rounded specimen being 9 in. long, and another with the edges only slightly rounded being a foot long. The gravel forms a small ridge that is cut through by the railway. A small patch of gravel at Sittles evidently once formed part of the same deposit.

About Hilliard's Cross, where the gravel rises above the general level of the terrace, a downward slope to the south, or away from the river, is easily recognised. The gravel is thin and several small pits reach the marl below it.

In the numerous pits near the junction of the canals, the gravel rises up to 10 ft. in thickness. The underlying marl has also been dug, and in that case the bottom of the pit is covered with water. The largest of the pits is now occupied by the canal reservoir. In this neighbourhood flints are present though not common, while granite and other igneous pebbles are rare.

Farther west there are numerous small pits in which the marl has been worked through the gravel. This is the case, also, close to the sides of the Bourne Brook, on the east side of which, near the railway, an old pit shows 15 ft. of gravel without reaching its base, while in one still in use 10 ft. of gravel with thin sand-bands can be seen, some of which are contorted. Here one flint was found. An old pit south of Riley Hill shows 5 ft. of gravel in which some of the pebbles are 8 or 9 in. long; there is a slight curvature in the stratification and an irregular depression or pipe in the gravel is filled with sand in a manner suggestive of the action of ice during its formation. On the south side of Ravenshaw Wood another slight rise in the gravel occurs and the terrace-like surface is locally lost.

West of the brook numerous small openings reached the marl beneath the gravel at a small depth, especially near Ashton Hayes and Handsacre. Where the gravel is thin it seems to be locally mixed with clay as if the underlying marl had been somewhat stirred up with it. Along most of this area the southern margin of the gravel and the adjacent marl slopes southward or away from the river. It will be seen from the details given that the flints decrease in numbers and practically disappear as the deposit is followed up the Trent valley. Clearly they have had an eastern origin or have been derived from the eastern drifts. E. E. L. D.

On the north side of the Trent, opposite Alrewas, this high level gravel extends northward from Wichnor beyond the area recently surveyed. Between Wichnor Village and the Park lodge the Trent has cut into both the first terrace and the marl-slope above it, forming a steep bank of Keuper Marl and gravel. Along this bank the gravels keep at about 230 ft. above sea-level, but they slope downward from it away from the river. In Wichnor Park the slope is not only continued in the marl, but a small valley has been cut in the latter near the gravel-margin, showing that there has been time for much denudation since the gravel was deposited. At the north end of the Park the gravel ends on a marl-flat, a slight rise in the latter taking place farther west. On the northern part of this flat flints are fairly numerous, suggesting that a thin skin of the gravel may have once covered it. The eastern margin is ill-defined. Many pits have been carried through the gravel to the marl for spreading over the gravelly land. In some cases the marl was worked for brick-making, probably because there is no better material near. Here also the matrix of the overlying gravel is more or less mixed with clay.

Some of the pebbles are large. On the western edge of the deposit, about a mile N.W. of Wichnor Church, a sandstone block 8 in. long was met with. Some of the quartzite-pebbles are split like those in glacial gravels. G. B.

RIVER DEPOSITS.

Alluvium and other river deposits have been widely spread in the main valleys of the Trent and Tame, and in the lower part of the Anker Valley, near its junction with the Tame. There is a considerable difference in the height to which they rise above the stream-level, the minimum being in the southern part of the Tame valley, while the maximum occurs near the junction of the Tame and the Trent.

The Alluvium, as shown on the map, corresponds to the part of the valley-bottom which is covered by ordinary floods, but the margin of the lowest terrace is seldom well-defined and is submerged by most of the heaviest floods.

The Alluvium of the Tame consists principally of silt, sometimes red marly silt, at others black peaty silt, while the terrace usually consists of sand and gravel and silt interbedded with marl-silt; but in the neighbourhood of Middleton there is little to distinguish between the two kinds of soil. T. E.

Northward, almost to the Bourne Brook at Fazeley, the lower margin of the terrace is indefinite, and the rise to the upper margin is small. There is no terrace on the eastern side of the river here and so nearly flat is the Alluvium below Dosthill that a more or less continuous skin of muddy peat has been formed.

Towards Fazeley the river-deposits are narrow but they rapidly widen farther north. The lower margin of the lowest terrace is defined here by a rise of some 2 ft., but the slope toward its upper margin is still small; in places especially near Bonehill, the surface is so flat that it is slightly peaty and part of it is liable to be covered by heavy floods. It is worth noting that the gravel turned out when making drains below the Alluvium in the area north of Fazeley contained few or no flints. About Coton and Comberford the terrace generally rises sharply from the Alluvium and the rise towards its upper margin becomes greater. G. B.

In the district between Hopwas and Alrewas, the Tame deposits a reddish silty mud derived from the debris of Triassic rocks. It rests on a sandy gravel containing flint-pebbles, evidently derived from the Eastern Drift, which still occupies considerable stretches on both sides of the river. Wherever it forms the bed of the river the gravel forms a firm bottom, and to its presence the old fords at Elford, Comberford, etc., owe their existence.

At Elford the terraces rise above the Alluvium with a well-marked step 3 to 5 ft. high, and the ground above, which is reached only by exceptional floods, rises gently towards the upper margin of the terrace. At Elford the terrace extends eastwards, and merges imperceptibly into a broad flat hollow running past Haselour Station to near Croxall Mill, where it is separated by a sharp fall of a few feet from the alluvial level of the Mease. The shape of the ground suggests that the Mease has once flowed into the Tame at Elford instead of into the Trent farther north. It is possible that part of the gravel of the hollow may be drift, but no line can be drawn between it and the river-gravel at Elford. The material of the terrace here contains little or no admixture of clay, and as the surface rises farther above the normal stream-level than in the area farther south, the light soil is apt to burn in dry summers. C. H. C.

In the neighbourhood of Alrewas these deposits attain their widest development. On the west side of the Tame, and for some distance up the Trent valley, the upper margin of the terrace abuts against the older gravel already described, but on the opposite side of the Tame it abuts against marl, suggesting a great amount of denudation on this side. A small patch, composed partly of marl and partly of the older gravel, rising like an island above the terrace, has been left by the vagaries of the Tame. Several sections occur in the terrace, the largest close to the railway near the north edge of the map. The gravels here are exceptionally well developed, and have been arranged as a long ridge trending north, a form which presumably resulted from the meeting of the flood-water of the two rivers. The pits are long and from 8 to 10 ft. deep. Gravel much preponderates over sand, which is unusual in the terrace-material. In a pit at the railway-junction a band of red sand with planes of current-bedding dipping northwards occurs about 3 or 4 ft. below the surface. Some of the pebbles are from 6 to 8 in. long, and there are various igneous rocks among them; flints are fairly common. The top layer of gravel is often laid irregularly on the sand as if occupying furrows scoured in it. The gravel is dug for ballast and for road-metal; the sand is used by the railway-company for sanding the rails.

A small pit recently opened in a field a little north of Wichnor Junction shows 2 to 3 ft., mainly gravel, resting on red false-bedded sand with subordinate gravel, the dip being again northerly. Some layers of coal-debris occur in the sand, while the pebbles are much as before, including small angular flints.

On the south side of the Trent, about and west of Alrewas, the terrace is well developed, and has an average breadth of about a mile. Sand predominates over gravel, and the only opening that has been met with lies a little north of Echills, four miles west of Alrewas. Eight feet of stratified, brightly-coloured sand and gravel are seen here, the sand predominating. One of the gravel-seams contains larger pebbles, some rounded, others semi-rounded, and among them fragments of igneous rocks, including granites, coarse and fine dykes, fine ash and fragments of apparently altered rocks, all clearly washed out of the western drift. In addition a few flints were found, one of which is a broken beach-pebble, with one of the original ends preserved and covered with characteristic nodes of percussion. No pebbles at all resembling it can be found in the eastern drift. It is becoming apparent that the flints of the western drift can be easily distinguished from those of eastern origin, for in a number picked up without any effort at selection, there is a far larger proportion of the more rounded or partly rounded flints in the western than in the eastern drift; indeed, in the latter they are mostly angular, small, and rather elongated. The terrace in this neighbourhood rises slowly, but on the whole steadily away from the river, and often attains a height of at least 15 ft. above the Alluvium. Moreover, where a branch stream enters the main valley its Alluvium often ends with a sharp drop on to the top of the terrace, not passing insensibly into that of the main river as in the southern part of the Tame valley. The effects of the oscillation of the river are well shown also by the fact that all but a small portion of the terrace of the north side has been cut away, and the modern Alluvium deposited against the marl, or locally against the higher gravel. On the east side of the Trent only a narrow belt of the terrace is left, and this has been eroded to some extent, for the terrace slopes locally toward the marl-bank, and indeed close to this bank has been cut through in places so as to expose the marl. To the south of Rylands the river-bank shows a section of the terrace consisting of gravel, sand, and sandy clay. Similar but smaller sections are exposed elsewhere in the river-bank. J. B. H.

Along the Anker a terrace is well developed. It surrounds an island of the flint-bearing Eastern Drift, and over much of it, near the island, flints are so common as to suggest that it has been formed by the river from that drift. It usually rises above the Alluvium with a well-defined step, but close to the Tame the step becomes less noticeable. Close to the north-east side of Tamworth Colliery, and at the east edge of the map, a rather sharply sloping plane, considerably above the normal terrace, has been cut in the Coal Measures. This may be part of the surface on which the drift-gravels were deposited, or a terrace-surface rapidly eroded, while the Anker was cutting its passage through the drift. G. B.

The stream that joins the Tame at Fazeley is known in the lower part of its course as the Bourne Brook, and is bordered by alluvium only; but its upper part, known as the Black Brook, flows through rather extensive flats composed of gravel and sand, often slightly peat-covered. The tributary streams have cut deep channels in the surface of this gravel, which must therefore be older than the alluvium. The hollows in which the gravel lies are too large to have been cut by the existing streams, and are probably connected with the glacial drainage and filled with gravel soon after the close of the Glacial epoch. They occur mostly in the districts of Wall, Shenstone, and Little Aston, and are coloured as terrace-gravel on the map. E. E. L. D.

Excavations[1] in the Square known as the Bridge in Walsall, in 1911, showed various old roads, and made ground down to 7 ft. 9 in. below the present street-surface. Below that depth followed in descending order:—Clean red sand, 1 ft.; black loamy gravel, 1 ft. 9 in.; yellow gravel, 1 ft. 6 in.; coarse clean wet sand, 6 ft. T. C. C.

PEAT.

The only instance where peat has accumulated at all extensively is at Norton Bog, between Chase Terrace and Norton Canes, in the west centre of the area described.

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[1] Information from Mr. John Taylor, Borough Engineer and Surveyor.

CHAPTER X.

IGNEOUS ROCKS.

NORTH WARWICKSHIRE.

By G. Barrow.

The igneous rocks of Dosthill are associated with the Stockingford (Cambrian) shales, as are those of the Nuneaton area, but show a less conspicuous tendency to extend in the form of sills along the bedding, and possess a different composition. The rocks are decomposed not only at the surface, but often for some distance below it, and in such cases are soft but rather tough, and persistently brown.

A large quarry has been opened in a mass lying to the east of the church, and in the southern corner, at a depth of about 50 ft., the base of the intrusion was reached. It descends with a curving surface till in the middle of the quarry it is fully 80 ft. below the surface, at the deepest point of the excavation. It cuts clearly across the bedding, which is quite recognisable though the shales are hardened. The intrusion thus appears to be of the nature of a sill with an undulating lower surface.

The rock is traversed by roughly parallel master-joints, trending N.N.W. and S.S.E.; minor joints cross these and locally produce a columnar aspect. Along some of the joints the rock is decomposed, but, as a rule, it is sound at a few inches distance.

Five thin slices (E. 11148-52) have been cut from specimens obtained in this quarry. They are described by Dr. H. H. Thomas as follows:

"These specimens all belong to the group of Proterobases, and have so many points of similarity with the Cornish Minverites that they may be fairly called Minverites. They are moderately fine-textured rocks of diabasic appearance. The microscope shows that they consist of brown hornblende, augite, olivine, biotite, albite-oligoclase felspar, and accessory iron-ore and apatite.

"The hornblende is the most conspicuous ferro-magnesian mineral, and occurs in large uniform ophitic crystals enclosing augite, olivine, and felspar, more particularly olivine, which occurs in pœcilitic fashion.

"The augite builds crystals of various sizes, but generally smaller than the hornblende, and is sub-idiomorphic in habit. It is usually colourless, but occasionally shows a pale lilac tint indicative of a moderate content of titanium. The lilac colour, however, is not so deep as is usual in the Minverites of St. Minver and other Cornish localities.

"Olivine is not found in an unaltered condition, but is always represented by serpentinous pseudomorphs. The mineral when enclosed by the hornblende seldom shows good crystal-form, but in the more felspathic portions of the rock characteristic crystal-outlines are occasionally met with.

"The biotite occurs in small proportion only, either alone or in association with hornblende with which it is intergrown. The felspar appears to be albite-oligoclase (decomposed). The iron-ore, which is most often associated with the hornblende and augite appears to be a magnetite rather than ilmenite, as the sections are mostly of a regular character. Apatite is moderately abundant, and is remarkable for its deep lavender colour, a colour often noticed in macroscopic crystals of this mineral, but much deeper than I ever remember to have seen in thin sections.

"The rock as a whole, as represented by the five specimens, E. 11148-52, is quite constant in mineral-composition and texture.

"The selvage of the sill, as represented in E. 11153, is a fine-grained micro-porphyritic compact rock marked by a segregation of pyrites which extends also into the shale in contact with the sill.

"The porphyritic constituents have extremely small dimensions and are mostly decomposed, but chloritic and serpentinous pseudomorphs appear to represent olivine and augite.

"The ground-mass consists of albite-oligoclase microliths arranged with approximate parallelism to each other and to the edge of the sill. There may have been some residual glassy matter, but this, if originally present, is now replaced entirely by calcite and chlorite."

In the outcrop on which the trigonometrical station is shown the rock proved too decomposed at the surface for commercial use. A boring to test the value of the underlying material passed through the base of the intrusion into baked dark shale at no great depth. A moderately sound specimen of the rock (E. 11163) was seen in microscopic section to have had originally much the same composition as that in the large quarry. In nearly all the other outcrops also the rocks are more or less decomposed, but they are mostly of the same nature as those described above. Thus a specimen (E. 11164) from the most southerly outcrop, according to Dr. Thomas, "still shows the original form of the olivine and augite crystals, though they are largely replaced by chlorite."

But in a few places a distinctly less basic type has been identified, as, for example, in the road leading down to the large quarry, close to the fault that crosses it. (E.11161—E.11162). Of this Dr. Thomas remarks "It is not quite certain that this difference in composition may not be due to differentiation, but no such variation was seen in the quarry itself, and similar material has been obtained elsewhere. (E. 11167). These rocks differ somewhat from those in the quarry described above; they are more or less completely decomposed and ironstained, and consist of albite laths, chlorite and calcite. They are very rich in colourless apatite, and appear to have keratophyric affinities."

Some of the numerous cracks and joints to be seen in the large quarry are infilled with minute veins of mineral material. Calcite is the most common, and strings of galena are fairly abundant.

SOUTH STAFFORDSHIRE.

By W. Gibson.

The South Staffordshire Coalfield, although it does not stand alone in containing igneous rocks intrusive into the Coal Measures of the Midlands, nevertheless presents some of the finest examples, and of these one occurs in the present area. From the quarried basaltic mass of Pouk Hill near Walsall, Allport obtained his type specimens, and next to that of Rowley Regis this locality still affords the best exposures.

In addition to that of Pouk Hill, outcrops of igneous rocks occur in the neighbourhood of the Bentley Faults, near Reeds Wood Park, west of Walsall, and again in a limited exposure at Brick-Kiln Wood, Essington; but while the igneous masses come to the surface only in these localities they are found to extend underground in numerous disconnected sheets as far north as the Landywood Fault, Great Wyrley. They are, however, unknown at the surface and in the many coal workings over the northern part of the coalfield.

The intrusions occur (1) as lenticular sheets from 0 to 84 ft. (Forest Colliery, Birchills) thick, usually inserted on the horizon of the Deep Coal; or (2) cutting across the measures, as dykes or bosses, ascend, though rarely, to the top of the Productive Measures, but have never been found traversing the Halesowen Sandstone and Keele groups.

Pouk Hill Quarry and another, though smaller excavation, 300 yards S.W. of the Pumping Station of the Birmingham Canal Company, near Reeds Wood Park, give good examples of an intrusive sheet; and a disused quarry, 500 yards east of the Pumping Station, shows a boss cutting abruptly across the measures, and altering a seam of coal on or about the horizon of the Bentley Hay Coal.

Some doubt exists as to the precise age of the intrusions. It is certain that they post-date the Upper Coal Measures, as is shown at Essington Wood; though whether the basalts were injected subsequently or previously to the faulting is still a debatable question; but if the mineralogical characters indicate a Tertiary, or at any rate a post-Triassic age, then the intrusions are long posterior to the main faulting of the district. In the absence of positive stratigraphical evidence to the contrary it is reasonable to place the intrusion of the Pouk Hill and similar basaltic rocks in the category of the Butterton-Swynnerton Dyke[1] of North Staffordshire, which pierces the Keuper Marl 16 miles north-west of Essington Wood.

Walsall District.—The often figured columnar basalt of Pouk Hill Quarry is familiar to students, but only a faint and rough columnar structure, seen on the west side of the excavation, now remains. The rock is exposed for about 60 ft., and it is said to extend for 20 ft. below the bottom of the quarry. That the basalt is intrusive is shown by its piercing the shales associated with the Fireclay Coal, which with its underclay, overlies the basalt on the north side. With the aid of intermediate exposures the basaltic sheet can be traced from Pouk Hill northward along the western side of Sneyd Brook valley, situated 300 yards S.W. of the Western Pumping Shaft (formerly the Victory Engine Pit) of the Birmingham Canal Company, where the intrusive character of the rock is again exemplified. The quarry lies on the upthrow side of the South Bentley Fault; on the downthrow side in the Victory Engine Pit, an igneous rock, 23 ft. thick, was entered at a depth of 16 ft. below O.D. Allowing for a difference in elevation it appears that the igneous rock is faulted down to the north for 366 ft.; but on the east side of Sneyd valley a basalt is at the surface along the South Bentley Fault 100 yards south of the Victory Engine Pit, and can be traced to the east into a disused quarry, 100 yards north of the fault which skirts the northern margin of Reeds Wood Park, where it abruptly cuts across and hardens some black shales, above the Bentley Hay Coal, which is 253 ft. above the igneous rock in the Victory Engine Pit.

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[1] 'The Geology of the North Staffordshire Coalfield,' *Mem. Geol. Surv.*, 1905, pp. 190-97.

Much igneous rock has been encountered underground between Short Heath and Leamore in working the Deep Coal; and under a cover of 36 ft. of Glacial Gravel was recently found at a depth of 93 ft. in a boring at Broad Lane Bridge, one mile N.N.W. of Bloxwich Church. The full thickness of the rock was not penetrated when the boring had reached a depth of 180 ft. An old shaft, 600 yards to the west of the boring reached the Bentley Hay Coal at a depth of 56 ft.

At Walsall Wood Colliery the No. 2 Shaft ended, at a depth of 1,752 ft., in 'green rock,' believed to be igneous, at 127½ ft. below the Yard Coal.

Near Essington, on the western side of the coalfield, and nearly on the same latitude as Walsall Wood Colliery, an igneous rock, surrounded by Etruria Marls, is poorly exposed in Brick Kiln Wood, one mile north of Holly Bank Colliery, in which igneous rock traverses the Shallow Coal in the form of 'white trap.'

The following notes on the petrological characters of the igneous rocks of South Staffordshire are supplied by Dr. H. H. Thomas.

"E. 9630. Pouk Hill Quarry,[1] Walsall. Fine-grained dark-grey compact micro-porphyritic olivine basalt. The rock consists of moderately abundant, green, serpentinous pseudomorphs after olivine, and labradorite felspars of about the same size, in a fine textured almost completely holocrystalline and ground-mass of labradorite, augite, olivine, and magnetite. The larger felspars, as well as those of the ground-mass, show some approximation to parallelism. The constituents of the ground-mass are all of very small dimensions. The felspars are not particularly slender, and the little augites are rather stumpy in habit. The magnetite forms larger individuals than the other constituents of the matrix.

"E. 9631. Same locality. Somewhat more coarsely crystalline than the above, but of even texture and similar in colour. A somewhat decomposed ophitic olivine dolerite. The augite is titaniferous, and the olivine pseudomorphs are plentiful. The felspars are lath-shaped and appear to be a medium labradorite. There is a certain amount of analcite which is in part primary, and a small quantity of green pyroxene, pointing to more than usual alkalinity.

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[1] For description of the Pouk Hill Rock, *see* Teall, 'British Petrography', 1888, p. 210; also Allport, *Geol. Mag.*, 1870, p. 170, and *Quart. Journ. Geol. Soc.*, vol. xxx, 1874, p. 547.

"E. 9632. Quarry near Pumping Station. An ophitic olivine dolerite similar to the above. It is, however, in a slightly fresher condition, some of the olivine having escaped decomposition. Interstitial analcite is moderately abundant and appears to be primary; in the neighbourhood of the analcite-patches the pyroxene occasionally is a green alkaline variety.

"E. 9633. Quarry north of Reeds Wood Park. Extremely fine-grained compact dark grey olivine basalt. Olivine occurs as pseudomorphs in minute phenocrysts, and, as in 9630, there are a few small felspars larger than those of the ground-mass. The ground-mass is more microlithic than in 9630, and has a good fluidal arrangement of the felspar microliths. Augite is confined to the ground mass, and is granular to microlithic. The rock might possibly be classed with the basic mugearites, but the felspars are perhaps too basic to permit of such a classification.

"E. 9637. 'White trap' intrusive into Deep Coal, Holly Bank Colliery. Palest-buff fine-grained rock. The rock is completely decomposed and impregnated with chalybite and other carbonates. Pseudomorphs exist after olivine, and the rock in its undecomposed state was probably similar to E. 9630.

"E. 9641. Disused quarry, Essington Wood. Extremely fine-grained, dark, grey compact micro-porphyritic olivine basalt. Olivine and felspar occur as phenocrysts as in 9630; but olivine is more abundant, and the texture of the ground-mass is finer. However, there can be no doubt that the two rocks belong to the same type."

CHAPTER XI.

ECONOMIC PRODUCTS APART FROM COAL.

POTTERY CLAYS.

Compiled by G. Barrow.

IN THE PRODUCTIVE COAL MEASURES.

Some good seams of clay and fireclay in the productive measures of North Warwickshire are extensively mined. The largest of the workings occur at Glascote, and to the south, at Wilnecote. At Glascote the clays have been raised for many years by Messrs. Gibbs & Canning. Two beds are generally worked, one a black clay (?fireclay), the other a fine, soft, white clay of special value. The clays occur quite at the top of the productive measures, and the higher of them may be contemporaneous with beds taken as Etruria Marls in other parts of the area; but at Glascote the associated strata have the characteristic aspect of Middle Coal Measures. The position of the beds can be fixed by comparing the section of the shafts from which the clays only are worked with the highest beds in the adjacent Glascote Colliery Shaft, a section of which was published in 1857.[1] The three small coal-seams shown near the top of the section of the Glascote Colliery are the three small seams given in the subjoined section. The red marl shown below the second thin coal almost always immediately underlies a valuable bed of white clay ("fireclay" in the Colliery section), the succession being almost identical in all the pits worked. This clay-pit lies about 300 yards N.N.E. of the colliery shaft; it was abandoned in 1875, and the plans deposited in the Home Office. The dip here was to the S.E. at 1 in 12.

SECTION OF THE BLACK AND WHITE CLAY PIT, NO. 3, GLASCOTE.

Messrs. Gibbs & Canning; communicated by Mr. P. A. Warden.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Soil	1	0	—	
Black clay	6	0	—	
Roche rock	27	0	—	
Rock	6	0	—	
Bind	8	0	—	
Roof clay	4	6	—	
COAL	1	5	53	11
Black clay	4	6	—	
Bottom black clay	4	2	—	
Rock	0	6	—	

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[1] *Geological Survey of Great Britain.* 'Vertical Sections, Sheet 21. The Warwickshire Coalfield.'

	Thickness. Ft.	In.	Depth. Ft.	In.
Bind, full of checkles	9	0	—	
Coal	0	6	72	7
White clay (seam worked)	4	4	76	11
Red marl (the distinctive bed)	4	6	—	
Ironstone	0	4	—	
Blue marl	10	0	—	
Ironstone	0	5	—	
Blue marl	5	4	—	
Rock, sharp	1	6	—	
Fireclay, black	0	4	—	
Blue marl, very good	8	0	—	
Blue marl, pockets of ironstone	4	8	—	
Bind with ironstone	13	6	—	
Black bat	0	6	—	
Coal	2	4	128	4
Fireclay, good with checkles	7	0	—	
Fireclay (without checkles)	5	0	—	
Bind	9	0	149	4

The clays were also mined from an old shaft situated close to the present waterworks reservoir, and starting high up in the Etruria Marls. Two new shafts have been put down at a site 300 yards due north of the centre of the reservoir; the white clay is worked, and again has the thin coal above it and the red marl, here containing nodules of sphaerosiderite, below it. A section of the beds to the first coal in No. 3 is given below; the remainder agrees closely with the section given above. The dip is between 10° and 15° in a S.E. direction. The base of the Etruria Marl is taken at 71 ft. down.

Section of New Clay Pit.
Messrs. Gibbs & Canning.

	Ft.	In.	Ft.	In.
Surface, soil and tough clay	6	0	—	
Fireclay	9	0	—	
Coal	1	0	16	0
Dark fireclay	9	8	—	
Red (Etruria) marl	23	4	—	
Rock, sandstone	6	0	—	
Bind	10	0	—	
Red (Etruria) marl	6	0	71	0
Black bind	1	0	—	
Rock	4	0	—	
Black shale	3	0	—	
Rock	7	6	—	
Bind	4	3	—	
Rock	6	3	—	
White clay	3	0	—	
Bind	6	0	—	
Coal (first seam in No. 3 pit)	1	9	107	9
Measures, to top of white clay	21	3	129	0

The works are known as the Glascote Terra Cotta Works. Terra cotta for architectural purposes, ornamental chimneys and white glazed ware are the specialities manufactured; but ordinary firebricks and sanitary pipes are also made. The workings in the Etruria Marl by the same firm have already been referred to.

The clays and fire-clays worked at Wilnecote by the firm of Messrs. Skey & Co. all lie below the Seven Feet Coal, and occur at a number of horizons, the lowest being well below the Bench Coal, the lowest seam mined for outside sale. The clays are of high quality, and some are of extremely fine grain, soft and unctuous to the touch. They contain many plant remains, and have yielded a fossil fish, but they rapidly disintegrate on exposure to the weather. These fine softer clays are not used alone, but are mixed with ground-up fire-clays containing a higher percentage of silica or quartz, in proportions which have been determined by experiment. The following are the chief horizons at which they occur.

The highest lies about half way between the Seven Feet and the Double Coals; it is a fireclay about 4 ft. thick, and has been mined from several pits, and is apparently mined from the new Beauchamp Pit. It underlies a seam of coal 2½ ft. thick.

The second is a specially good seam of softer clay, and has been mined from most of the Wilnecote pits. It underlies the Double Coal, much of which is taken with it and used for calcining.

The third lies a little below the Bench Coal, and is separated from it by a thin band of alum-shale.[1] It averages some 3 ft. thick and is a hard fire-clay, much used and ground-up for mixing with No. 2, the soft unctuous clay.

The fourth is a hard yellow unctuous clay averaging 3 ft. in thickness. It occurs between 60 and 70 ft. below the base of the Bench Coal, and immediately underlies the lowest coal in this district.

One or more of these beds have been worked from all the pits on the north side of the road; in most of the older ones the clays have largely been taken out and two new shafts, the Beauchamp Pits, have recently been sunk to work two of the beds further north. These pits start a few yards above the Seven Feet Coal, and are carried to a depth of 235 ft.

Mr. Irvine Bailey, managing director, kindly supplied three samples of these clays for examination and analysis:—

No. 1.—Hard clay, underlying a thin coal-seam about 40 ft. below the Seven Feet Coal.

No. 2.—White clay, underlying the Double Coal; about 75 ft. below the Seven Feet. This clay is specially valuable and much worked.

No. 3.—Unctuous clay, separated from an overlying thin bed of coal by a foot of brown clay. It occurs about 200 ft. below the Seven Feet Coal.

The specimens were examined and analysed at the Government Laboratory. The report is given below:—

Report on some Warwickshire Clays by the Government Laboratory, December, 1915.

"Rational" or "Proximate" analyses of clays dried at 105°.

	No. 1, Hard Clay.	No. 2, White Clay.	No. 3. Unctuous Clay. Hard Clay Shale.
Clay Substance	53·64	72·66	93·32
Quartz	45·84	26·72	6·40
Felspar	·52	·62	·28
	100·00	100·00	100·00

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[1] This shale was formerly used for the manufacture of alum and sulphuric acid; but the work has been abandoned and the premises taken over by Messrs. Skey & Co. They are shown as Vitriol Works on the former six-inch map.

Calculated from Ultimate Analysis.

	No. 1, Hard Clay.	No. 2, White Clay.	No. 3. Unctuous Clay. Hard Clay Shale.
Clay Substance	47·21	55·12	77·08
Quartz	45·99	22·80	3·31
Felspar	6·80	22·08	19·61
	100·00	100·00	100·00

The accuracy of the results, as determined for clay substance and felspar by "rational" analysis, is open to considerable doubt. The matter has been discussed by H. Ries in 'Clays' (New York, 1906), pp. 66, etc., and at some length by J. W. Mellor in 'Quantitative Inorganic Analysis' (Griffin), p. 657, etc.

Comparison between the results of the "Rational" analysis and those calculated from the "Ultimate" analysis shows that the felspar found in the "Rational" analyses is in all cases very much lower than that calculated on the assumption that all the sodium of potassium oxide is present as felspar. The values for quartz are very much closer, and in five cases are in satisfactory agreement. The "Rational" analysis is of considerable value for determining the proportion of quartz, but of doubtful value for ascertaining the clay substance and felspar in different kinds of clays. (*See* also Ries, 'Clays,' p. 67).

Ultimate Analysis.

	No. 1, HARD CLAY. Mean.	No. 2 WHITE CLAY. Mean.	No. 3. UNCTUOUS CLAY. Hard Clay Shale. Mean.
Silica SiO_2	69·67	60·35	48·07
Titanic oxide TiO_2	1·06	·92	·98
Alumina Al_2O_3	18·21	24·21	31·06
Ferric oxide Fe_2O_3	·76	1·11	1·20
Ferrous oxide FeO	·64	·50	.92
Iron pyrites FeS_2	·04	·06	·06
Zirconium oxide ZrO_2	·03	Nil.	Nil.
Nickel oxide	·01	Nil.	Nil.
Manganous oxide MnO	·04	·01	·01
Calcium oxide CaO	·53	·48	·58
Strontium oxide SrO	Nil.	Nil.	Nil.
Barium oxide BaO	tr.	·01	·01
Magnesium oxide MgO	·64	·83	·77
Potassium oxide K_2O	·86	2·85	2·55
Sodium oxide Na_2O	·19	·57	·45
Lithium oxide Li_2O	·05	·09	·07
Phosphoric oxide P_2O_5	·05	Nil	Nil.
Sulphuric anhydride SO_3	·04	·04	·02
Chlorine Cl.	·04	·03	·02
Carbon dioxide CO_2	·07	·06	·02
Water above 105° C. H_2O	5·86	6·27	9·16
Water up to 105° C. H_2O	1·58	1·79	3·61
Carbon (organic) C	·12	·20	·89
Hydrogen (organic) H	·04	·03	·05
	100·53	100·41	100·50
Loss on ignition	7·57	8·28	13·81

An attempt was made to determine the organic matter more accurately than is usually considered necessary in clay analysis. The method consisted in determining the water given off at 1,000° C. on heating the clay in a stream of dry carbon dioxide. The total water formed after ignition in air or oxygen is also determined. The difference, amounting from 0·2 to 0·4 per cent. is taken as water formed from hydrogen combined with carbon. The carbon present otherwise than in the form of carbon dioxide is determined as follows:—The total carbon is calculated from the amount of carbon dioxide by burning the clay in a current of dry oxygen at 1,000° C. From the carbon so found there is deducted the amount due to the carbon present in the form of carbon dioxide, as determined by the treatment of the clay with hydrochloric acid in the usual way. The difference is due to carbon present either as free carbon or as organic matter. The amount of hydrogen found in all cases is small, but there is no doubt as to its presence as distinct from that in combined water and water expelled at 105° C., seeing that the differences referred to above are altogether beyond the limits of experimental error. The high ratio of carbon to hydrogen suggests that the carbon is present mainly if not wholly either as free carbon or as coal.

Physical Tests.

	No. 1. Hard Clay.	No. 2. White Clay.	No. 3. Unctuous Clay.
Tests on unburnt material—			
Specific gravity at 15·5° C.	2·592	2·624	2·519
Plasticity number	16·3	24·8	23·2
Shrinkage on air-drying	5·0%	5·0%	6·0%
Tensile strength; lbs. per square inch	129·0	186·6	148·6
Texture—			
Clay substance...	37·15%	25·56%	65·86%
(Average diam. mms.)	(·0089)	(·0097)	(·0076)
Silt	10·15%	67·59%	5·15%
(Average diam. mms.)	(·0298)	(·0142)	(·0310)
Dust sand	4·36%	3·62%	3·05%
(Average diam. mms.)	(·0343)	(·0386)	(·0413)
Sand	48·29%	2·38%	24·40%
(Average diam. mms.)	(·226)	(·1248)	(·265)
Tests on burnt material—			
Specific gravity at 15·5° C. if material burnt to 1,200° C.	2·604	2·491	2·554
Shrinkage at 500° C.	5·0%	5·0%	6·0%
,, 800° C.	5·0%	5·0%	8·0%
,, 1.000° C.	5·6%	8·2%	9·6%
,, 1,200° C.	7·2%	10·4%	10·4%
Porosity after burning to 1,200° C....	4·57%	0·08%	1·93%
Fusing point	Cone 27-28 1680° C.	Cone 26-27 1660° C.	Cone 29-30 1720° C.

The texture was determined by "Schoene's Method" as described in Ries' 'Clays,' p. 138.

The actual dimensions of the particles as measured are shown in the table.

The *fusion point* was determined by the use of Seger's Cones; the temperature of the fusion as determined from the cone is also given in the table. According to Ries' classification all the clays are semi-refractory. The second of the clays is on the border line between low and semi-refractoriness. This clay produces ware of great compactness as shown by the low porosity of the material burnt at 1,200° C.

In a few cases the clays of the productive measures have been dug in openworks in North Warwickshire, and a small pit is still open on the east side of the road a little north of Two Gates (Wilnecote); but practically all the clays from this part of the Carboniferous rocks are now obtained by mining them in association with coal.

Coal Measure clays have been worked for bricks at a number of localities along the eastern margin of the exposed South Staffordshire Coalfield. In the north there was a small brickyard 100 yards north of Wandon Lodge, at the north-western corner of Beaudesert Park. Pale-red and yellow bricks are made from clays and soft yellow and grey sandstones opposite the school north-east of Cooper's Lodge near Rawnsley. Bricks were made from surface-clay immediately west of the Eastern Boundary-Fault at Red Moor (Cannock Wood), and red bricks are still made for colliery use at Cannock Chase No. 7 Plant, close by. At Wimblebury some clays under the so-called Old Man's Coal were extensively dug about 1898 at some large clay-holes, and used for the manufacture of firebricks and buff terra-cotta ware. At Heath End, Pelsall, the clays associated with the Deep or Bottom Coal were worked for bricks in three open pits. At Winterley near Daw End some green shales at the base of the Coal Measures were so employed.

The grey coal-measure clays about the horizon of the New Mine Coal are used in brickmaking north of Willenhall. Of recent years a buff-coloured brick of superior quality is obtained from the weathered shales that form numerous and large spoil heaps around the old workings in the Diamonds Ironstone between Willenhall and Walsall.

IN THE ETRURIA MARLS.

Both in South Staffordshire and North Warwickshire the Etruria Marls are extensively dug in open pits for the manufacture of the well-known 'Staffordshire blue bricks,' tiles, etc. In South Staffordshire blue bricks and tiles are made on a large scale between Walsall Wood and Aldridge. These red clays have long been worked in open excavations, as mentioned by Jukes,[1] and form an immense store of readily available material. In 1911 five pits were in operation, varying from 70 to 100 ft. in depth and several hundred yards in width. The clay is quarried (some of the harder bands need blasting) in several lifts or stages, broken up with the hammer, drawn up an inclined railway, mixed, ground and tempered, and moulded into various forms of bricks, floor-tiles, roofing-tiles, ridge-tiles, kerbstones, drain-pipes, etc., which are then fired at a high temperature. The value of the clay is due to its containing so much iron oxide or carbonate as to produce, when fired a fusible silicate of a slag-like hardness. The degree to which the blue vitreous condition permeates the finished product depends on the extent of the firing.

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[1] South Staffordshire Coalfield, ed. 1, 1853, p. 282; ed. 2, 1859, pp. 30, 31, 98, 102, 175.

Roofing tiles and fancy bricks are made from the lower beds of the Etruria Marls at Littleworth (north-east of Cannock). In past times bricks were made from red clay, presumably belonging to the same formation, at a pit in the angle between Brick Kiln Street and High Street, Brownhills (p. 114). This pit may be the one north of Catshill alluded to by Jukes[1] as in existence in his time (1849). The Etruria Marls were also worked at Clayhanger and at Goblin's Pit Farm, half-a-mile west of Walsall Wood church.

At Walsall Wood Colliery red marls are raised from an open clay-pit, about 50 ft. deep, and made into pale-red and yellow-mottled bricks and agricultural drain-pipes. These marls, unlike those of Aldridge described above, are deficient in iron, and will not yield blue bricks; their position in the Coal Measure sequence is discussed on p. 115.

At Littleworth, Bridgtown and Essington the lower 200 ft. of the Etruria Marls are extensively used for the manufacture of terra-cotta wares, tiles, bricks, etc.; but all attempts to utilize the higher beds cropping out west of Cheslyn Hay have been unsuccessful.

In North Warwickshire there are large excavations in the Etruria Marls for making bricks, tiles, etc.; the largest are at Cliff, Whateley, Tame Valley, and Wilnecote village. At the last-named there is a specially good band of dark-grey, but not carbonaceous, clay which is taken out separately and used for high-class terra-cotta; somewhat similar bands occur at other pits, but do not appear to be worked separately. All these large excavations lie near the western side of the coalfield, the Etruria Marls being feebly represented or absent on the eastern side.

IN THE KEELE BEDS.

During the construction of the reservoir on Barr Beacon an unsuccessful attempt was made to produce blue bricks from the red marls of the Keele Beds (p. 121); but the clays proved to be deficient in iron.

In North Warwickshire also these marls have been tried, but it was found they contained too much lime; when burnt the bricks swelled up, lost their shape, and at times burst.

OTHER CLAYS.

Silurian.—Near Walsall the weathered surface-clay of the Wenlock Shales has been used for bricks at the Paddock Brick-works north of the Chuckery, but the works stopped in 1910. Unless the clay is freed from all particles of limestone, and is so thoroughly weathered as to contain little calcium carbonate, the brick disintegrates.

Permian? and Trias.—A band of red marl in the Hopwas Beds was used for bricks at Wandon (p. 128); another at the top of the

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[1] *Op. cit*, Ed. 1, 1853, p. 282.

Upper Mottled Sandstone was utilized at Chasetown (p. 142), while others, in the Lower Keuper Sandstone, have been turned to account at Brereton and at Chase Terrace (p. 147).

Keuper Marls have been used at Rugeley, also west of Brereton, at Coldwell near Gentleshaw, and at Cannock Wood (p. 151). They often make good house-bricks, but are not used now in this district, as it is cheaper to make bricks where the clays (Carboniferous) and coal occur close together.

IRONSTONES.

SOUTH STAFFORDSHIRE.

The raising and smelting of the local ironstones, formerly an important industry, between Willenhall and Walsall has now practically ceased, owing chiefly to the exhaustion of the local supplies; but numerous old shafts with their spoil banks, and the ruins of old furnaces and iron-works, surrounded by extensive slag-heaps, bear striking witness to the former activity of the industry.

The cause for the concentration of ironstone-mining and smelting within this small area was the amount of coal and ironstone found within moderate depths, as will be gathered from the following table giving the position of the ores in relation to the coals—the Heathen Coal in this area marking the upward limit of the ironstones:—

			Thickness. Feet.
	Heathen Coal.		
(6.)	Lambstone and Brownstone Ironstones	and Measures	44 to 56.
(5.)	New Mine Ironstone		
	Pennystone Ironstone		
	Sulphur Coal and measures		21 to 52
	New Mine Coal and measures		21 to 35.
	Fireclay Coal and measures with Poor Robin Ironstone		21 to 46.
	Bottom Coal and measures		5 to 30.
(4.)	Gubbin and Balls Ironstone measures		18 to 50.
	Mealy Grey or Singing Coal and measures		16 to 50.
(3.)	Blue Flats Ironstone measures		10 to 14.
(2.)	Silver Threads Ironstone measures		6 to 15.
(1.)	Diamonds Ironstone measures		162 to 348.

Of these ores those chiefly mined were the New Mine, Gubbin and Balls, Blue Flats, Silver Threads, and Diamonds. In the south of the area at Rough Hay, near Darlaston, the Heathen Coal is only 42 ft. beneath the surface, and, as the measures rise steadily to the north, the underlying deeper layers of ironstone and coals gradually come within easy reach until near the Bentley Faults the Blue Flats Ironstone is nearly at the surface. North of the Bentley Trough only a small quantity of ironstone was raised, except towards the outcrop east of Birchills and Bloxwich, in part due to the greater depth to the ores, but apparently also to a deterioration in the iron-contents.

The ironstones occur in layers of nodules or tabular masses in shale or clod, all belonging to the clay-ironstone variety except the Brownstone ore, which resembles the Black Bands of North Staffordshire and Scotland. Most of the nodules contain cracks infilled with white clay, which occasionally bears blende, galena, chalcopyrite, pyrites, calcite, and dolomite. The yield per acre ranged from 1,200 tons (Poor Robins) to 2,400 tons (Blue Flats).

1. *Diamonds*, 2. *Silver Threads*, 3. *Blue Flats.*—The associated measures vary slightly in thickness and character, but do not appreciably depart from the following section at Bentley:—

		Ft.	In.
3. Blue Flats ...	Ironstone	0	4
	Binds	3	0
	Ironstone	0	1
	Binds	1	6
	Ironstone	0	2
	Binds with ironstone nodules	9	8
2. Silver Threads	Ironstone	0	1
	Binds	1	0
	Binds with ironstone ...	3	4
	Ironstone	0	2
	Binds	6	0
1. Diamonds ...	Ironstone	0	3
	Binds	1	4
	Ironstone	0	2
	Binds	1	5

4. *Gubbin and Balls.*—At Bentley the section towards the centre of the area is:—

	Ft.	In.
Balls of ironstone...	0	3
Clunch	2	0
Ironstone	0	4
Clunch	1	0

Representatives of the ironstone are found as far north as Brownhills, but the horizon is chiefly recognised in the area between Wolverhampton and Walsall.

5. *New Mine Ironstone.*—This is a widely distributed bed over the central and southern part of the South Staffordshire Coalfield, which, varying slightly as to detail, gives the following section at Bentley:—

	Ft.	In.
Ironstone	0	3
Clunch	0	7
Ironstone	0	4
Clunch	3	3
Ironstone	0	4

6. *Brownstone Ironstone.*—This is confined to the Bentley district below the Heathen Coal as follows:—

	Ft.	In.
Heathen Coal	—	
Clunch	0	10
Clunch and ironstone	9	0
Ironstone (Lambstone)	0	3
Clunch	2	6
Black batt	1	0
Ironstone (Brownstone)	0	6
Clunch, ironstone—black batt	3	3
Measures with some ironstone	14	10
New Mine Ironstone	1	6

The following analyses[1] illustrate the composition of 1, 2, 3 and 4 in the Darlaston district:—

Analyses of Ironstones.[1]

	1	2	3	4
Protoxide of iron	40·01	40·39	42·34	49·04
Peroxide of iron	2·46	2·38	1·47	3·39
Protoxide of manganese	0·75	0·75	1·12	0·79
Alumina	0·46	0·19	0·59	0·21
Lime	2·58	7·30	3·89	0·70
Magnesia	2·70	2·16	1·48	0·57
Soluble silica	0·27	0·18	0·35	0·27
Potash	0·19	0·07	—	0·10
Carbonic acid	29·13	33·35	30·91	30·80
Phosphoric acid	0·21	0·22	0·25	0·18
Sulphuric acid	—	—	trace	—
Bisulphide of iron	0·06	0·11	0·06	0·11
Water, hygroscopic...	0·39	0·33	0·28	0·26
Water, combined	0·72	0·60	0·73	0·77
Organic matter	1·06	0 80	0·56	0·60
Insoluble residue	18·77	10·52	15·50	12·15
	99·76	99·35	99·53	99·94
Metallic iron...	33·28	33·44	34·41	40 81

A partial analysis of a blackband from Bloxwich gave as much as 30·17 of organic matter with 25·34 per cent. metallic iron. Brownstone from Bloxwich contained 0·98 per cent. organic matter and 35·95 per cent. metallic iron.

At the northern end of the coalfield, in Beaudesert Park, iron-ore was raised on a very small scale and smelted with charcoal, even in the Middle Ages; and in other parts of the same district, along the streams more remote from the outcrops, the sites of less ancient bloomeries may still be identified by the heaps of scoriae, as at Dutton's Pool, at Fair Oak House, at the Sheepwash (near Smart's Buildings), and at Baland's Pool, all situated along the valley between Rugeley and Hednesford. The ore is believed to have been obtained chiefly from bands just above the Old Park Coal, and from others immediately below the Old Man's Coal.[2]

About Rushall and Walsall, the ironstones known as the Blue Flats, Silver Threads, and Diamonds (pp. 91-94), below the Bottom Coal, were worked extensively by shallow shafts and crop-holes. These crop-workings begin at Daw End, where a number of shallow old diggings cover a field immediately west of the disused 'church' and range south-westward to Rushall Hall. Here the outcrop passes under the Glacial drift, and was not worked; but it emerges along the north side of Mellish Road (Walsall), where workings were resumed. These works near Rushall were alluded to by Plot in 1686.

On the south side of Walsall the same bands were met with in the well of the Highgate Brewery (p. 93), and in old times had been worked at the crop between Belvidere Road and Gorway Road, as was pointed out to us by the late Mr. W. H. Duignan.

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[1] 'Iron Ores of Great Britain,' pt. ii, *Mem. Geol. Surv.*, 1856, pp. 160, 158, 156, 152.

[2] G. M. Cockin, 'The Ancient Industries of Cannock Chase,' *Trans. Burton-on-Trent Nat. Hist. and Archæol. Soc.*, vol. v, 1906, p. 126.

A little clay-ironstone is still raised as a by-product at some of the collieries. A seam of blackband ironstone, and some associated cannel, in the roof of the Four-Foot Coal at Walsall Wood Colliery, are said to yield oil. The ironstone will calcine by itself, and yields lumps of partly fused ore; but this is said by the smelters to be too siliceous for their purpose.

NORTH WARWICKSHIRE.

Ironstone was at one time extensively mined in the northern part of the Warwickshire coalfield; indeed the amount raised probably exceeded that of coal. It occurs in the shales (binds) as lines of nodules, sometimes small but numerous, but often large, of irregular shape and in rare cases coalescing to form a band. In the neighbourhood of Glascote and Wilnecote there are a number of small old shafts with dumps of shale, from which the ironstone was raised. All record of their working has been lost, but they serve to show how much material had to be brought to the surface in extracting the ironstone. A few heaps of a similar nature may be seen around some of the older collieries, but for the most part they have been covered up by more recent waste. Only where coal and ironstone were worked together, as in the case of the White Ironstone, is any coal-debris to be found in the old waste-heaps. The iron-ore was smelted exclusively by charcoal, and, where possible, a smelting-house was placed close to a stream, so that the bellows could be worked by water-power. One of these, known as Hints Forge, and shown on the one-inch map, was situated on the south side of the Bourne Brook, about 900 yards E.S.E. of Hints Hall, and 3 miles W.S.W. of Tamworth. It was marked by a large slag-heap which has recently been carried away to be re-smelted.

As already stated there are no records of the smaller and older mines, but in 1856 the production of the iron-ore in Warwickshire was 48,000 tons.[1] This may not have been the maximum, for the succeeding years show a fall in progress. In 1858 it was 29,500 tons, the value of the ore being 7s. 4d. a ton; in 1863 it was 12,500, with an average value of 5s. This fall both in production and value coincides with a rapidly increasing use of cheaper ores, especially the Cleveland ironstone, of which 865,000 tons were raised in 1853, and 1,490,000 tons in 1860. The small quantity still raised was probably in demand for making a finer brand of iron; and this may account for the subsequent increase in output which continued with variations till 1870. Soon after the close of the Franco-Prussian war a great rise began in both the production and price of iron-ore, and in 1875 the annual yield for Warwickshire rose to over 97,000 tons, of an average value of about 10s. a ton. At the end of 1878 the district shared in the great slump in prices and output, the total raised in 1879 being a little over 16,000 tons, but the value remaining much the same as before. An increased demand having set in for higher class iron the industry revived somewhat, 36,000 tons being raised in 1882, the price being 9s. a ton. The new demand, however, led to the search for foreign high-grade ores, and as these came increasingly into use the output from Warwickshire dwindled till in 1902 only 91 tons were raised.

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[1] Mineral Statistics of the United Kingdom.

As no records of the oldest workings have been kept it is not possible to say at how many horizons the ironstone-nodules have been mined. In the northern part of the field the known workings have been mostly if not entirely in the White Ironstone, a name applied to the band or bands that occur in the shale (bind) immediately above the Smithy Coal. This band is still worked with the coal, but neither is worked separately. Information from Mr. Grayston shows that the ironstone occurs in balls, often of large size, and that where these are well developed the yield is from 850 to 900 tons to the acre. It was worked at Glascote and Amington for some years by Messrs. Onions, Featherstone & Co. till 1879, when the slump in the iron-trade occurred. It is still worked when there is a demand for this type of stone, but except for this the industry is extinct.

To the south the stone was mined at Kettlebrook Colliery, where the following section was presented:—

Kettlebrook Colliery (Caggs Shaft).

	Ft.	In.
Blue bind	8	6
Brown ironstone	0	4
Dark bind...	1	6
Brown ironstone	0	6
Dark-coloured clunch	1	6
Light bind	0	6
SMITHY COAL	2	4

In the area to the west and south-west of this shaft small old pits are numerous, but no ironstone was worked from the old Wilnecote shaft of Messrs. Perrin & Harrison, although the royalty extended over part of this area.

In the ground now occupied by Messrs. Skey & Co., at Wilnecote, ironstone appears to have been mined at three horizons. The Black Ironstone, in the shale a little below the Bench Coal, was most in request, and appears to have been worked out over the Peel royalty.

The Brown Ironstone, also worked to some extent, lies about 15 ft. below the Seven-Feet Coal. The highest bed worked here is called the White Ironstone, although it occurs below the Smithy Coal instead of above it. At Wilnecote and to the south at the Tame Valley pit, the stone occurs in three lines or layers, and is locally known as the Three-band Ironstone. Still further south the ironstone at this horizon was worked extensively at Hockley Hall, and to the west of the railway near the present open shafts is a specially large shale-tip. The ore was also worked at the same horizon at Dosthill, still occurring in three bands.

The depth to the ironstone was 378 ft., and the section of the beds worked was as follows:—

Dosthill.

	Ft.	In.
Top stone	0	3
Blue bind	2	9
Stone	0	2
Rock	0	6
Bottom stone	0	2

The old pits for ironstone appear to be restricted to the outcrop of the Middle Coal Measures; indeed they are rare on the higher beds even of this division. It would appear therefore that the White Ironstone associated with the Smithy Coal was the highest seam worked.

BUILDING-STONE.

The Wenlock Limestone at Walsall has been used for occasional walling and building-purposes, Rushall Church (19th cent.) being an example of the latter use, but the stone is now seldom employed for these purposes, although, at Daw End, blocks 2 or 3 ft. in length can be obtained. No building-stone is raised from the Coal Measures, the few sandstones that occur being too soft and friable; moreover, most of the outcrop within Sheet 154 is covered with Glacial drift.

The upper part of the Lower Keuper Sandstone was being quarried at Beaudesert in 1910 for fine interior work at the Hall, and a little has been raised at Red Moor, near Cannock Wood. The rock is a fine-grained buff or light reddish-brown freestone. The lower part of the Keuper Sandstone is generally too soft and friable to be useful. The church at Ogley Hay, built about 1850 from stone raised at Hammerwich, shows much disintegration from the weather.

Little sandstone is now quarried in North Warwickshire, for bricks are cheaper as a building material, and when stone is required it is obtained from elsewhere. There are many old quarries in the Coal Measure sandstones, but these rocks are mostly too friable to make a useful building-stone. The condition of the church at Tamworth shows how badly they stand exposure to the weather.

LIMESTONE AND LIME.

The Barr or Woolhope Limestone, which has been burnt for lime from early, possibly Roman, times, was much in request in the district during the canal-building era over a century ago for hydraulic works on the locks, bridges and aqueducts. Being argillaceous it made a dark ('black') lime, which is said to have fetched £1 a ton. The quarries were still at work in Murchison's time (*circa* 1839), but have been idle for about 30 years. The works were all opencast with the exception of a single shaft sunk through a thin cover of Wenlock Shales in the valley south-west of Aldridge Lodge (p. 16). The nodules of limestone were freed from the accompanying shale and burnt in open horseshoe-shaped kilns.

The two bands of Wenlock Limestone have likewise been worked for centuries, not only for lime, but also as a flux for the iron-smelters. In the reign of Edward II (1307-1327) one Robert Bond rented three acres of waste land in the Birchills, near Walsall, on condition that he should not make any mines of limestone in the same. Leland (*c.* 1540) mentions pits of coal and lime at Walsall.[1]

The only limeworks in operation in 1911 were the Phœnix Limeworks of Mr. John Brawn at Daw End. The stone is raised from the Lower or Thick Limestone by a shaft. Some of it is sent away for flux; the rest is burnt in large open kilns conveniently adjacent to a canal. It makes a grey lime, used chiefly for building purposes. An analysis of the lime, made in 1896 by Mr. F. H. Allcock, F.I.C., F.C.S., showed 90 per cent. of caustic lime, 2·75 per cent of carbonate, 1 per cent. of iron and alumina, and 6 per cent. of silica. The limestone at Daw End is not used for roadstone, nor, with few exceptions, has it been employed for building. A cement-works has lately been established at Linley for the manufacture of cement from the Lower Limestone. A company lately burnt lime from the same band, and also raised a small quantity of pale-green clay, known to the workmen as 'lill,' and offered for sale as 'fuller's earth'; but the works were idle in 1911. The shaft, which is situated on the northern side of the Midland Railway, midway between Daw End and Rushall church, seems to have been sunk on the line of the fault described on p. 17; the so-called 'fuller's earth' appears to be in some way an accompaniment of the fracture.

The Nodular Beds above the Lower Limestone appear to be suitable for the manufacture of cement. The following analysis shows the composition of these beds at Daw End.[2] Samples were taken over a thickness of 90 ft. from the Lower Limestone upward, limestone-nodules and shales being mixed together. An average sample of this mixture was then dried at 212° F., and analysed with the following results:—

Silica	13·70
Alumina	5·18
Oxide of iron	1·29
Oxide of manganese	trace
Lime	42·70
Magnesia	1·50
Sulphur	0·14
Phosphoric acid	trace
Carbonic acid	34·90
	99·41

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[1] For early allusions to the working of limestone, ironstone, and coal in this neighbourhood, *see* Thomas Pearce, 'The History and Directory of Walsall,' 8vo, *Birm.*, 1813; also F. W. Willmore, 'A History of Walsall and its Neighbourhood,' 8vo, *Walsall*, 1887; and 'Records of Rushall,' 1892. In these the earlier references are quoted.

[2] Information supplied by Mr. John Brawn.

SAND.

Sand for glass-making and for moulding-purposes was formerly obtained from the Glacial drift at Ryecroft sand-pits, north of Walsall (p. 182). Moulding-sand is raised from the Upper Mottled Sandstone of the Bunter at Ogley Hay (p. 142).

Building-sand is dug from what may be the Hopwas Beds at the base of the Bunter Pebble-Beds along the north-western side of Beaudesert Old Park from Wandon to Littleworth; from the outlier of the same beds at Cannock Wood (p. 129), from the Bunter Pebble-Beds at Shire Oak, and from the Lower Keuper Sandstone east of Chasetown (p. 147). It has been obtained from the Glacial drift at Ryecroft, at the West Bromwich Street pit in Walsall (p. 182), and at other small pits opened in the drift as occasion demanded.

Sand and fine gravel are obtained from the large pit in the Glacial beds at Hopwas (p. 124); smaller quantities are obtained from the river gravels, about the sides of the Trent and the Tame near their junction.

ROADSTONE.

The principal sources of roadstone are the igneous rocks, the Bunter Pebble-Beds and the larger stones screened out of the bedded Glacial sands and gravels.

Igneous rocks.—The rock quarried at Pouk Hill near Walsall resembles the Rowley Rag of Rowley Regis, and is associated with the Middle Coal Measures. It is broken up on the spot into fine chips, which are sent by canal for facing or top-dressing first-class roads within and without the district. The 'green rock' obtained from the mines furnishes a suitable stone, but the outcrop at Pouk Hill is the only one that yields a good material.

The igneous rock quarried at Dosthill is associated with Cambrian shales. Small paving-setts are made, and road-metal is sent away by a wire-railway to the canal on one side and to the Midland Railway on the other.

Pebble-Beds.—There are many pits in the Bunter Pebble-Beds in which the larger stones are screened out for road-metal. Fairly large stones broken to small pieces give a small proportion of round surfaces and form a good binding material. The bulk of the pebbles being of quartzite they form a durable surface, so long as the stones remain fixed. Pits in these beds occur to the west of Brereton, at Stile Cop, Moor's Gorse, Shire Oak, and Barr Common, in the north-western and western area, while others occur near the Barracks about Shenstone and Weeford; a rather large quarry is situated close to the side of the road a little west of Hopwas.

Glacial Gravels.—The larger stones in these gravels can be more readily screened out than those in the slightly coherent Pebble-Beds. They are worked at Cannock, and have practically replaced Bunter pebbles as a source of road-metal. A similar gravel is used at Hopwas, but here there is a smaller proportion of large stones, and Bunter pebbles are still in use.

Blast-furnace slag of modern type is used to a small extent in some parts of the district; the older slags are unsuitable for road-making.

AGRICULTURE.

The district here described includes part of an industrial area, of which Birmingham is the centre. The concentration of the population in towns has led to a local demand for market-garden produce, and has influenced the character of the farming. The amount of vegetables raised is further increased by a large number of allotment gardens cultivated by the miners and other workmen. One of the industries gives an impetus to corn-growing, for a large quantity of straw is used in packing the more fragile forms of pottery-ware, and is obtained direct from the farms. There is a fair amount of ground laid down to grass, but less than in the less thickly populated areas, only sufficient permanent pasture being retained for the use of the cows required for the milk-trade. The soil varies according to the character of the rocks, but largely also according to the extent and thickness of the drift by which much of the rocks are covered. The drift forms an essentially light soil, but though of a gravelly nature the more widespread unbedded drift generally contains some clay, and does not burn as readily as the bedded sands and gravels, which are more local in their occurrence. The unbedded 'drift' forms a fairly good market-garden soil. It covers much of the Keuper Marl area to the south-east of the Hints Fault, but it is usually of no great thickness, and contains moisture held up by the marl below. Light, but fairly good, soil is formed by the Keuper Sandstones, and still lighter by the Bunter Sandstones; the Pebble-Beds of the latter give rise to markedly dry soil, and much of the ground formed by them is either planted or open common-land. The heavier land is formed mainly of the Keuper Marls to the north of Lichfield and north of Tamworth, where there is but little drift. The marls, however, form a fairly good soil, especially for corn-growing.

In the part of Warwickshire included in Sheet 154 the best soil is formed by the Keele Beds, the marls of which carry specially heavy corn-crops. At the opposite end of the scale are the sandstones of the Newcastle Group, some of which would form poor soil if large quantities of manure were not available. In the area between Walsall and Willenhall the original soil has been completely buried under the spoil-heaps of mines and furnaces; the area is now a barren and unsightly waste.

WATER SUPPLY.

The area here described is capable of yielding a large quantity of good water. The greater part of the supply is obtained from the Bunter Sandstone and Pebble-Beds, which easily head the list as water-bearing beds; others yield considerable amounts, while a few, though covering large areas, yield little or none.

Cambrian Shales and associated *Igneous Rocks.*—The Cambrian shales yield little or no water, but the associated igneous rocks are traversed by joints and cracks which yield sufficient for small domestic supplies.

The *Silurian Limestones* of the Walsall area are resorted to only by private houses or farms where the public supply is not available. They are not suitable for large supplies, and indeed exhaustive pumping would lead to the drawing in of surface-water.

The *Middle Coal Measures* are not used for any but small supplies. Locally some of the thicker and more persistent sandstones yield water, but they are generally fine-grained and not markedly porous; moreover they often occur as wedges, and unless a wedge happens to outcrop at the surface, or is in contact with some water-bearing beds, no water can get into it.

The *Etruria Marls* in the Warwickshire area yield little or no water, as the Espley Rocks associated with them are firmly cemented by clay and carbonates at no great depth below the surface; but in South Staffordshire the Espley Rocks often have a sandy and porous matrix, and may yield a good supply. The Township of Cheslyn Hay obtains its supply from a well sunk into one of them south of the Hayes.

The *Halesowen Sandstones* can be relied on to yield well provided that there is a good collecting surface, and that the shaft or bore is put down at no great distance from the outcrop. During the sinking of the Kingsbury Colliery shafts great difficulty was found in coping with the water.[1]

It has been pointed out on p. 45 that these sandstones have been cemented by interstitial clay and carbonates, and unless they are decomposed water cannot circulate freely in them. This was illustrated in sinking the new shaft at Woodend, where the lowest thick sandstone was solid and practically impervious till the lowest 6 ft. was reached, when a large body of water was encountered. A still greater quantity was met at Kingsbury, which is much nearer the outcrop.

The *Keele sandstones* also yield a large amount under favourable conditions, but the interstitial cement may for a time hinder the passage of water. In shallow excavations it may be observed that only the lowest inch or two of a small bed of sandstone is decomposed and permeable, the remainder being compact. A shaft and boring made in these rocks by the Tamworth Board is said to have yielded well, but the water was hard, as would be expected in view of the calcareous character of most of the sandstones. When completely decalcified Keele sandstone may be as porous as Bunter, as was shown in the well at Hopwas, from which the Tamworth supply is obtained. The water rises from a bed of Keele sandstone, into which it has descended from the Bunter, which must rest directly on this sandstone or be faulted against it close by. The Keele sandstone is here remarkably porous.

The outcrops of the Keele sandstones also give out abundant springs in the Hints area, one of which supplies the village.

The *Bunter* and the *Hopwas Breccia*.—The Bunter Sandstones and Pebble-Beds form the finest underground reservoir in this and the surrounding district. Wherever a large sheet of them is tapped the yield is always great, and from them most of the more important wells draw their chief supply. The sandstones are coarser in texture than the generality of those of the other formations, and the conglomeratic bands are often extremely permeable. In places the beds are slightly calcareous, though there is considerable variation in this respect, and the water is slightly but not inconveniently hard.

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[1] J. P. Kendrick, 'Sinking Operations at Kingsbury Colliery, Warwickshire.' *Trans. Fed. Inst. Min. Eng.*, vol. xiii, 1898, pp. 269–276.

These sandstones and pebble-beds are present either at the surface or underground over at least two thirds of the district. Wells and borings have been made in them at various points, but not within the eastern area, where the overlying Keuper Marl attains a considerable thickness. Not only does the Bunter there lie at a considerable depth, but it may be absent near the margin of the Warwickshire Coalfield. Apart from this, in the district between the Hints fault and the Tame, rain has no ready access to the Bunter, and though there may be a large body of water in the rock, it would probably be heavily charged with salts. But in the ground between the Tame and the Anker the Bunter yields a large supply of good water in the Lullington Boring.

During the sinking of the pits at the Littleton Colliery, in the Cannock area, some valuable information was obtained as to the total amount of water in the Bunter, and the extent to which it may descend through porous bands in the underlying older rocks that crop against its base. A detailed account of the sinkings has been given by Mr. Bailey,[1] and from it the following information has been taken. The total amount pumped was 966,834,600 gallons. Toward the later stages of the pumping, when the maximum was being raised, the well of the South Staffordshire Water Works Company at Huntington, some 700 yards to the south, was drained below pump-level; in other words a cone of exhaustion with a radius of 700 yards and a depth of at least 200 ft., was produced. The other phenomena are complicated by the fact that a great amount of tubbing had been inserted under the Kind-Chaudron system (where no pumping takes place) before the second attempts to sink the pits were made. The tubbing appears to have been carried below the base of the Bunter, and it is difficult to say how much of the Bunter water was shut out, but it is important to note that a great volume entered the shaft through one or more beds of porous Carboniferous sandstones which acted as conduits from the Bunter. Differences in volume from the various sandstones seem to be explicable by the varying porosity of the rocks, and the varying depth below the surface of the base of the Bunter. It is clear that under certain circumstances it is advantageous to continue a well below the base of the Bunter.

The experience gained at the Littleton Pits and at the Huntington pumping-station both show that the level of the water in the Bunter is capable of being lowered by heavy pumping. Under similar circumstances the water-level in the Chalk about London was locally restored by pouring partially filtered water down a well into large galleries. Possibly the water-level in the Bunter might be raised during the winter months by admitting flood-waters of the Trent through suitably placed boreholes.

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[1] 'The Sinking and Equipment of the Littleton Collieries,' by T. H. Bailey, *Trans. Fed. Inst. Mining Eng.*, vol. xxxix, 1909–1910, pp. 418–456; pl. xi, xii.

The *Keuper Sandstones* generally yield a fair amount of water, the sandstones in the lower part of it being thick and not appreciably less porous than some of those in the Bunter. The yield is then great, as is shown by the well at Fradley to the north-east of Lichfield (see p. 275), where, however, it is possible that the Bunter was reached and is contributing.

Generally the sandstones are of finer grain than those of the Bunter, and especially those of the upper part of the group which will yield no more than is sufficient for a domestic supply. The rocks as a whole are also more calcareous, and the interstitial cement seems to be more permanent than in the other formations.

Keuper Marls.—For the most part the marls yield little or no water, and wells sunk in them often go dry in summer. The basal beds, however, contain numerous sandy bands and thin skerries which yield more than would have been expected, as in the well at the Tamworth Brewery. Unless unfavourably situated they usually yield sufficient for a house or farm, but no large supplies can be obtained from them.

Drifts.—The Drifts of this area are mostly of a gravelly nature and absorb much of the rainfall, so that they formed the original source of supply in areas where the underlying rocks are of a clay nature, such as the Coal Measures of South Staffordshire and the Keuper Marl.

Where a public supply is available most of these wells have been disused; indeed the water in the superficial deposits has become contaminated where the population is dense. But elsewhere wells in the Drift are still in use and generally yield fairly good water. The scattered cottages at Cannock Wood and Gentleshaw depend on wells, varying from 20 to 100 ft. deep, sunk in Glacial Drift, but in some cases continued into the Keuper beneath. In this western area the Drift is so thick as to preclude surface-pollution except in a densely populated district. In the eastern or Keuper Marl area it is usually thinner, but on the other hand the dwellings are more scattered and the danger of the pollution is less. Thus a spring from the drift supplies Drayton Manor, near Fazeley, and the method adopted there for its use has been resorted to in other cases. The surface of the marl beneath the Drift is uneven, and forms hollows down which the underground water travels. Where the drift is not thick the situation of such hollows is shown by the persistence of moisture in the early stages of a dry spell. The ground is opened or a well sunk, and if the supply is sufficient and the form of the ground suitable, the water is raised by hydraulic ram.

River Gravels.—A fair amount of moderately good water can be obtained from the river-gravels of the Anker and the Trent above the junction with the Tame. The water in the Tame gravels is distinctly foul and smells badly in hot dry weather when the river is low, but at a distance from the river where there is a distinct rise in the ground, and the water is working its way underground towards the river, a small quantity of fairly good water may be obtained. There are few if any such places actually within the area, but they are not uncommon a short distance to the south where the slightly higher gravels make a wide spread.

SPRINGS.

There are numerous springs in the district, though many have been dried up by the pumping in the broad central belt of ground, stretching north and south, within which the majority of the pumping stations are situated. Springs from the Bunter (including the Hopwas Breccia) have been most affected, as the bulk of the water is obtained from it. In this formation there is a more or less free passage for the water from top to base, and the water-level is lowered as a whole, but in the Keuper Sandstone marl-partings are thicker and more persistent, and there is less passage of water from one bed to another. Springs from the thicker beds, when favourably situated, may be but little affected by the pumping. The springs from the drifts are not usually affected by the pumping, and there is still a great number of them.

In the north-western part of the district springs issue from the base of the Bunter in the Cannock Chase area, where it often rests on the impermeable clays of the Coal Measures, as, for instance, on the Marquis's Drive, half a mile south-east of Moor's Gorse (p. 128). The base of the Keuper Sandstone where it rests on a marl-band occasionally throws out a little water, as at the Springs (half a mile south of Brereton), and again at Upper Longdon. A few springs are thrown out at the base of the Keuper Marls, *e.g.*, the Nun's Well at Cannock Wood, the Coldwell at Gentleshaw, and at Beaudesert. Springs also issue from the base of the Glacial Drift at Bose's Well (Cannock Wood) and at Goscote Lodge Farm, midway between Pelsall and Rushall.

In the area about Lichfield the persistent marl-partings throw out a number of springs from the more important beds of Keuper Sandstone, which, in addition to supplying the adjacent houses, occasionally serve to fill ponds or small lakes. A series of the stronger sources occurs at Maple Hayes, about a mile west of Lichfield, at the spot indicated by the words 'Conduit Heads' on the map. The water is raised by a ram to the Hall and supplies the lake. Another good spring occurs near Farewell Church to the north-west of the last. A little to the north-east of the city is the St. David's Well, while to the south-east numerous good springs supply Freeford Hall and Swinfen Hall besides maintaining two large ponds. Southward at Weeford the Bunter gives out a powerful spring that is led to a ram and supplies all the surrounding houses. In the area south of Weeford, where the Bunter and Hopwas Breccia generally rest on impermeable marls, many springs, mostly small, are given out along the sides of the numerous hollows and shallow valleys by which the area is intersected.

In the Keuper Marl area, between the Hints Fault and the Tame, many springs issue from the base of the overlying Drift, some capable of supplying a house, but the majority small and dry during long droughts. There are few springs in the ground between the Anker and the Tame to the north of Tamworth, but south of the town, in the coalfield area, there are a fair number. As the various sandstones mostly dip into the hill they give out little water, but where the outcrop is cut open by a stream springs are fairly numerous. A specially large one rises from a sandstone of the Halesowen Group, where the outcrop has been cut into by a little stream about 1,200 yards N.E. of Wilnecote Church.

The most powerful springs, however, are those thrown out along faults. Along both the Hints fault and that which bounds the western side of the Warwickshire Coalfield, almost impermeable Keuper Marl has been faulted against water-bearing rocks, thus forming a retaining wall behind which the water is impounded. The highest points of the wall are on the crests of the ridges between the valleys, and here no water can escape; the lowest are in the valleys, and here the springs are most powerful and numerous.

In the Hints area much water still escapes in the vicinity of the Hints Fault, but at and north of Hopwas the overflow was formerly very great. A series of strong springs used to issue at the foot of the bank at the edge of the Alluvium, and near Tamhorn Park the water overflowed the barrier of Keuper Marl in such volume that a 12-in. pipe was required to carry it off to the river. Presumably all the water in the Bunter above the fault, with much of the water collected on the Keele Sandstones to the south of Hopwas, found its escape here, and the circulation along the fault-face has rendered the rocks so porous by decalcification that the water passes through and down almost to the alluvial level. No water was found in a well to a depth of about 50 ft. close to the cottage above the Devil's Dressing Room.

Little water now issues from these springs, as the pumping at the Hopwas well keeps the water-level practically at river-level, which is 2 or 3 ft. lower than the margin of the Alluvium at which the springs formerly escaped.

The course of the Western Boundary Fault of the Warwickshire Coalfield is marked at many points by powerful springs. Commencing at the southern end there is a strong spring at a small farm marked on the one-inch map a little west of the point where the Birmingham railway crosses a little stream to the south of Cliff. At this point there is marl at each side of the fault at the surface, but the water comes up from the Keuper Sandstone, and in such quantity that it keeps the marls in a state of sludge and the ground quick. Many cartloads of old bricks have been thrown into this to render it safe.

Northward of this the Cambrian Rocks descend nearly to the alluvial flat, and almost all along the hill-foot and near the fault springs emerge, a few of which are noted on the six-inch map. About 180 yards south of Wigford Farm a large body of clear, bright water may be seen in dry weather issuing at the foot of the river-bank. It comes from the mouth of a drain-pipe laid to carry off the water rising from the Keuper Sandstone;

beneath the Alluvium at the foot of the steep bands. The clearness of the water is in noticeable contrast with the foulness of that within the Alluvium itself. A large quantity of good water could be collected here.

The condition of the Keuper Sandstone about Wigford shows that the rock becomes thoroughly porous and disintegrated when it is so situated that a free circulation of water is possible, and the whole of the interstitial calcareous material may be removed.

Along the western branch of the Dosthill Fault a powerful spring of pure water rises on the west side of the Tame a few yards north of the canal-aqueduct. Before the installation of a public water-supply it was much resorted to by the inhabitants, and is still used by a few in summer-time.

A fault has been proved in the Kingsbury Colliery to pass close to the south-east corner of Kingsbury Wood, with a throw of about 120 ft. While along most of the escarpment the Keele Sandstones dip into the hill and the water follows this dip, near the fault they dip outward from the hill and give out springs. The strongest rise in a small extension of the main wood called the Dumbles on the six-inch map. The circulation of water has reduced the calcareous Keele Sandstone to a mass of loose sand. One of these springs is impounded in a small reservoir, and supplies by gravity part of the Kingsbury area (Tamworth Rural District).

MINERAL SPRINGS.

Farther north, under Dosthill House, two mineral springs rise close to the river-side; the more powerful is saline, and contain 460 grains of mineral matter to the gallon, nearly the whole being sodium chloride. The other is a chalybeate spring, and the existence of the two together caused the house close by to be for some years used as a sanatorium or spa. The old salt-bath is still in existence, though much dilapidated, as is also a small reservoir into which ferruginous water oozes. The occurrence of these springs in line with others of pure water is difficult to explain. No bed of salt has been met with in wells or borings, and the only salt water known was found in the lower part of the Coal Measures in the Tamworth Colliery. Though the lower beds of these measures must be on the east side of the fault at Dosthill at no great depth down, no salt water has been elsewhere recorded from the mines. It is, however, a remarkable fact that the salt water at Tamworth Colliery was met with only when close to the continuation of this fault; it there came from the coal-face in large quantity. The amount of salts, almost entirely sodium chloride, is remarkable, being 2,300 grains to the gallon, or 2,900 parts to the 100,000.[1] It occurs in that part of the Warwickshire Coalfield which lies nearest to the western end of the Leicester Coalfield, where salt water is persistently present in the lowest coal seams[2]. It would appear that the salt water is travelling in the coal-seams, but only in the immediate neighbourhood of the fault, and that therein lies the explanation of its absence in the other Warwickshire mines. Farther north springs of pure water issue from the fault.

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[1] These were kindly testedby Mr. J. S. Firth, Science Master at Tamworth Grammar School.

[2] 'The Geology of the Leicestershire and South Derbyshire Coalfield' (*Mem. Geol. Survey*), 1907, p. 109.

NOTES ON THE PRINCIPAL WELLS AND PUBLIC AND PRIVATE SUPPLIES.

Much the largest amount of water is pumped by the South Staffordshire Water Works Company, which supplies all the towns and many villages outside the Tamworth District, with the exception of Rugeley, Brereton, and Cheslyn Hay, which have their own supplies. The greater part of the water is obtained from wells sunk into or through the Bunter Sandstone and Pebble-Beds. In and near this district the Company has 10 wells in operation, which together supply over 15,500,000 gallons a day. For particulars of the wells see p. 271.

The public water-supply of Tamworth and the surrounding district is under the management of the representatives of the town and surrounding villages or rural districts. After numerous trials had been made and the waters tested, it was decided to sink a well at Hopwas, and from this nearly all the supply is now obtained. The well is situated on the north side of the Lichfield Road, half a mile west of Hopwas. It was sunk under the superintendence of Mr. H. J. Martin, and was described by him in the Report of the British Association for 1882 (pp. 222-226), from which the following particulars have been taken:—The well was sunk in 1879, and the ground-level at the top is 306 ft. above Ordnance Datum. The depth from the surface is 168 ft., and the diameter 10 ft. Before pumping the water stood 129 ft. down; continuous pumping for 59 days gave an average of rather over a million gallons a day, the water falling 28 ft. 7 in. or to a depth of 157 ft. 7 in. below the surface, leaving 10 ft. 5 in. at the bottom of the well. After the test pumping was stopped the water rose rapidly, and at the end of three weeks it stood slightly higher than at the commencement, although a fair amount of water was still being pumped. The water stands 177 ft. above Ordnance Datum, or 11 ft. above the summer-level of the Tame, which is about half a mile distant. The analysis is as under:—

Temporary hardness	6·13
Permanent hardness	3·50
Total hardness	9·63
	grains per gallon.
Chlorine	1·61
Total solids	25·06

The water is pumped to a reservoir on Glascote Hill, to the east of Tamworth, and from this it descends by gravity; small local mains supply the area close to the well.

A section of the beds passed through is given on p. 279. The first 16½ ft. consisted of scree or downwash from the hill of Pebble-Beds behind the waterworks; the rocks below belong to the Hamstead Group, from the fact that the associated conglomerates contain quartzite, limestone, and other far-travelled material. The water which rises from the sandstone at the base of the well is shown by its analysis to be Bunter water which has passed down. The conditions which have led to the pounding-up of water here by a fault are described on p. 221.

The rocks in the neighbourhood of the fault are fissured, possibly some little movement having resulted from the yielding of the marl on the opposite side of the fault. One of these fissures, met with in the well at a depth of 112 ft., acts as a weather-glass, air entering when the barometer is rising, and escaping when it is falling. A similar fissure was met with when sinking a well in the hill-face further south.[1]

Kingsbury, in the extreme south of the Tamworth district, is in part supplied from a reservoir filled by a spring from the lower Keele sandstones (see p. 222).

The result of the tests of water made by the Tamworth Board (p. 223) was summarised by Mr. Martin in the Report of the British Association for 1887, p. 366. It was found that the water from the river-gravels east of Tamworth in the Anker valley contained from 38·47 grains of solids per gallon, and a permanent hardness of 14·8 to 16, a higher degree than would have been expected from such deposits. The well-water at the Brewery (formerly the Workhouse) contained 43·4 grains of solids per gallon and a permanent hardness of 18·63, which from the nature of the beds would be expected.

The springs which issue near the foot of the long hill about Hopwas and Hints vary in composition, but the majority contain slightly over 29 grains of solids to the gallon, and a permanent hardness ranging from 6·8. Wells in these rocks generally contain more material in solution and a considerably greater permanent hardness.

An instructive borehole was put down just above the Midland Railway viaduct at Bolehall, on the south side of Tamworth, in Keele Beds, and not in Waterstones as stated. The water, which still overflows at the surface in small quantity, contains nearly 48 grains of solids to the gallon, with a permanent hardness of 17·58. This shows the character of deep-seated water from the Keele Beds, which are cemented by carbonate where they have not been decomposed. A section of the beds passed through in this boring is given on p. 279.

Another boring was made in the Alluvium of the Anker to the east of Moor Farm, about a mile N.E. of Tamworth. After passing through 7½ ft. of superficial deposits the boring entered the Keuper Sandstone, and was continued in it to a depth of 82 ft. The water was so saline as to be useless, but it is not known whether the soluble material was sodium chloride or not. A section of the beds passed through is given on p. 280.

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[1] On this subject see 'The Movement of Air in Fissures and the Barometer,' *Nature*, vol. xxvii, 1883, p. 375. Also *Geol. Mag.* for 1919, p. 168.

Another boring was made close to the Hall at Coton, about 1½ miles W.N.W. of Tamworth. After passing through the unusual thickness of 40 ft. of river-deposits it entered the lower beds of the Keuper Marl, and continued in them to a depth of about 120 ft. from the surface without finding any water, possibly owing to the fact that the bands capable of absorbing water at the surface crop out far away from the spot. A section of the beds passed through is given on p. 281.

Another trial for water was made near Hurley, in the extreme south-east corner of the map. A shaft was sunk to a depth of 26 ft., and a boring below was carried to a depth of 142 ft. The whole was in Keele Beds, the base of which, however, must have been nearly reached. The yield was considerable but the total was not tested, nor is there any published account of the quality of the water. A section of the beds passed through is given on p. 281.

Rugeley (Sheet 140) and Brereton share a supply obtained from two bore-holes in the Bunter Pebble Beds, situated half a mile north-west of Smart's Buildings, 2 miles west of Brereton. The water overflows at the surface, and is led to a covered reservoir at Slitting Mill (Sheet 140), whence it is distributed by gravitation. The water is of the usual Bunter type.

The Township of Cheslyn Hay, south of Cannock, obtains its water-supply from a well sunk in the Etruria Marls south of the Hayes (Sheet 153).

Hints and the adjacent dwellings are supplied from a spring that rises in the face of the hill opposite Hints Hall. The water is led to a ram, by which it is forced to a reservoir on the top of Hints Hill.

Weeford, farther up the valley, is similarly supplied from a spring issuing from the Bunter, a ram forcing the water to a sufficient height to supply the surrounding houses.

PRIVATE SUPPLIES.

There were formerly many private wells in this district, but most of them have been superseded by the public supplies, and it is now difficult to obtain any accurate information about them. One of these wells[1] forms one of the few cases where the Bunter failed to give a satisfactory supply. It is situated in the Gorse Covert, at Chestall, and was made to supply Beaudesert Hall, a little to the north. It consisted of a shallow well with a boring carried to a depth of 356 ft. from the surface, which is 705 ft. above sea-level. The section is as follows:—

		Thickness. Ft.	Depth. Ft.
Drift	Gravel and sand	64	64
Keuper Marl ...	Red marls with sandstones	109	173
Keuper Sandstone	Sandstones, grey, white, and red, with marls	78	251
Bunter Pebble-Beds	Conglomerates and sandstones	105	356

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[1] Information supplied by Mr. G. M. Cockin, F.G.S.

The position of the base of the Keuper Sandstone is uncertain; it may be somewhat lower than 251 ft.

Armitage.—The Swan Inn. Six-inch map Staffs. 46 S.W.

About 260 ft. above Ordnance Datum.

Made and communicated by Messrs. C. Isler & Co.

Old well to 31½ ft.; new boring from base to 132 ft. Lined with 80 ft. of 5 inch tubes to within 2 ft. of surface, and well filled in to within 3 ft. Water-level 11 ft. down; yield 600 gallons an hour.

In Keuper Sandstone to about 100 ft.; then 20 ft. of conglomerate, which may be the basal bed of the Keuper or the top of the Bunter; beds below undoubtedly Bunter.

City Brewery Co., Lichfield.—In angle formed by the railways a little south of the city. Six-inch map Staffs. 52 S.W.

About 300 ft. above Ordnance Datum.

Old shaft to 58 ft.; boring below to 200 ft. When the boring was made the water rose 24 ft. in the old well, or to 34 ft. from the surface. Full yield not tested; amount pumped is about 2,300 gallons an hour. Well mainly in Keuper Sandstone; boring wholly in the Bunter.

Lichfield Brewery.—About 500 yards N.E. of the above.

Made and communicated by Messrs. Le Grand & Sutcliff, 1884.

Sunk well to 44 ft.; boring below to 178 ft. Water-level 27 ft. down. Yield 1,800 gallons an hour.

The beds passed through are much the same as at the City Brewery.

Tamworth Brewery.—A little north-west of the bridge over the Tame on the south-west side of the town. Six-inch map Staffs. 59 S.W.

The well is 100 ft. or more deep, and sunk in the lower beds of the Keuper Marl, yielding a fairly large amount of water which is hard, containing over 40 grains of solids to the gallon.

Elford Low Farm, Tamworth.—Close to the high road, 3 miles north of Tamworth. Six-inch map Staffs. 53 S.W.

About 240 ft. above Ordnance Datum.

Made and communicated by Messrs. Duke & Ockenden, 1905.

Boring throughout; lined with tubes to a depth of 93 ft. from surface. Water-level 56 ft. down; water met with at 106 ft.; more at 148 ft.; a large feeder was struck at 192 ft. which gives an abundant supply.

Shuttington House, Tamworth.—On south side of Ashby Road, 3 miles N.E. of Tamworth. Six-inch map Warwick. 2 N.E.

About 260 ft. above Ordnance Datum.

Old well 53 ft.; boring below to 112 ft.

Sunk in the lower part of the Keele Group; the boring was mainly in red marl and sandy marl (called 'binds' by the borer). No water was met with till a bed of hard sandstone near the base was pierced; the water then rose rapidly to within 50 ft. of the surface. The yield is ample, and there is no appreciable fall on pumping; as it is for a private house it is not severely tested.

APPENDIX I.

SHAFTS AND BORINGS.

1.—Shafts and Borings for Coal.

(*a*) The South Staffordshire Coalfield.

Aldridge Colliery Shaft-section.

A mile N.W. of Aldridge. Six-inch Map, Staffs. 57 S.E.
Lat. 52° 37′ 8″ N. Long. 1° 55′ 49″ W.
Height above O.D., 500 ft. Date, about 1874.
Communicated by Mr. W. F. Clark, M.I.C.E., F.G.S., Manager.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Made ground	19	0	19	0
Soil	1	0	—	
Sand and clay	19	6	—	
Red marl	25	0	—	
Red marl and loam	31	0	—	
Soft red marl	15	0	—	
Red marl	15	0	—	
Red and spangled marl	56	0	—	
Red rocky marl	24	0	—	
Red spangled marl	18	0	—	
Red rock	3	6	—	
Mottled marl	29	0	—	
Rocky marl	45	0	—	
Red marl	20	0	—	
Strong green rock	18	0	—	
Red spangled marl	21	0	—	
Red rocky marl	17	6	—	
Strong red marl	30	0	—	
Mingled ground	4	6	—	
Black ring	0	2	412	2
Soft rock	15	0	—	
Dark fireclay	9	0	—	
Green grit rock	10	0	—	
Mottled marl	30	0	—	
Green grit rock	5	0	—	
Rock binds	4	3	—	
Mottled marl [*Base of Etruria Marls*]	14	0	499	5
Coal ring, black bass and fireclay	1	9	501	2
Grey binds	5	5	—	
Black bass parting	0	6	—	
Red fireclay	6	2	—	
Coal	1	0	514	3
Fireclay	1	9	—	
Hard rock binds	13	5	—	
Fireclay binds	3	6	—	
Hard fireclay	4	7	—	
Mingled marl	6	1	—	
Hard rock binds	8	9	—	
Hard rock	2	1	—	
Fireclay	1	0	—	
Hard fireclay	1	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Fireclay	8	9	—	
Black shale	0	6	—	
Fireclay	2	2	—	
Black shale, coal and black batt	2	3	—	
Dark fireclay and black batt	3	0	—	
Fireclay binds	12	8	—	
Rock binds	35	0	—	
Coal and batt	3	3	624	0
Dark ground	5	0	—	
Fireclay	3	5	—	
Dark ground with gubbin ironstone	7	4	—	
Coal and batt	3	0	642	9
Dark fireclay	2	7	—	
Coal and batt	12	0	657	4
Fireclay and clunch	9	6	—	
Rock and peldon	4	6	—	
Blue binds	9	6	—	
Rock	5	0	—	
Blue binds	2	8	—	
Coal	1	0	689	6
Clunch	6	8	—	
Hard clunch	2	8	—	
Peldon	3	0	—	
Binds	2	6	—	
Dark binds	3	6	—	
Peldon	6	6	—	
Dark binds with ironstone	4	9	—	
Dark binds	7	6	—	
Light binds	1	6	—	
Coal, black batt and coal	2	6	730	7
Hard fireclay	3	0	—	
Light rock	1	0	—	
Black shale, fireclay and black batt	4	0	—	
Light rock	1	6	—	
Blue binds	19	6	—	
Dark binds	9	0	—	
Coal. Seven-Foot Coal	7	6	776	1
Fireclay	2	8	—	
Coal and batt	1	0	779	9
Black ground	3	3	—	
Gubbin ironstone measures	6	0	—	
Black batt	1	0	—	
Coal. Four-Foot Coal	4	0	794	0
Hard rocky fireclay	7	0	—	
Grey rock	8	6	—	
Black parting	0	6	—	
Rock binds	8	6	—	
Dark clod and binds with ironstone	9	9	—	
Coal, 2 ft. 6 in. Parting, 6 in. Coal, 3 ft. 0 in. } Five-Foot Coal	6	0	834	3
Dark fireclay, hard	5	0	—	
Light fireclay with ironstone	4	6	—	
Grey binds	6	0	—	
Coal	1	6	851	3
Light fireclay	8	6	—	
Dark binds	2	6	—	
Grey rock	2	0	—	
Dark clod and bass	5	6	—	
Coal. Brooch Coal	2	6	872	3
Black clod and shale	12	0	—	
Grey rock	18	0	—	
Binds	3	6	—	
Clunch	7	6	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Light rock	14	0	—	
Mixture of fireclay and clunch	5	0	—	
Dark binds	37	0	—	
Strong grey rock	3	0	—	
COAL	1	0	973	3
Fireclay binds	10	3	—	
COAL. LITTLE COAL	1	6	985	0
Bright [? light] rock	17	6	—	
Rock and binds	58	1	—	
COAL	1	3	1,061	10
Rock and binds	8	0	—	
COAL	1	3	1,071	1
Rock and binds	48	3	—	
COAL	1	8	1,121	0
White, grey, and peldon rock	51	3	—	
COAL	1	8	1,173	11
Peldon and rock binds	45	4	—	
COAL. YARD COAL	3	6	1,222	9
Rock binds	29	1	—	
COAL	1	9	1,253	7
Rock and fireclay	42	0	—	
COAL	1	6	1,297	1
Rock binds	30	1	—	
COAL. SHALLOW AND DEEP COALS	13	9	1,340	11
Ironstone (gubbin)	5	1	—	
Blue binds and fireclay	21	11	—	
Blue flats [ironstone]	4	3	—	
Blue binds	25	5	1,397	7

It is not known to which of the two shafts this section refers. In the original from which the above is copied the depths to the coals are slightly different and may have been obtained by plumbing.

Brereton Collieries.—1. *The Old Engine Pit,* one mile S.W. of Brereton. Six-inch Map, Staffs. 45 S.E.

Lat. 52° 44′ 15″ N. Long. 1° 55′ 38″ W.

Height above O.D. about 397 ft.

Communicated by Mr. Edgar G. Sutherland, late Manager.

	Thickness. Ft.	In.	Depth. Ft.	In.
Made ground, ashes, etc.	24	0	—	
Sand	2	0	—	
Red clay	2	0	—	
Grey marl	4	0	—	
Rock bind	2	0	—	
Fireclay with ironstone-bands	18	0	—	
COAL [SECOND COAL]	6	3	58	3
Fireclay	16	3	—	
Blue bind	2	7	—	
Fireclay	2	4	—	
COAL 0 ft. 10 in. Fireclay 1 ft. 0 in. COAL 1 ft. 6 in. Fireclay 0 ft. 2 in. COAL 0 ft. 2 in. [THIRD COAL]	3	8	83	1
Fireclay	7	6	—	
Rock	0	9	—	
Blue bind	0	3	—	
Sand-rock	1	9	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Blue bind	2	3	—	
Sand-rock	1	9	—	
Grey bind	5	10	—	
Hard rock with water	5	3	—	
Blue bind with bands of ironstone	17	7	—	
Blue bass with bands of ironstone	4	10	—	
Dark bind...	3	10	—	
Coal [a chance coal]	2	0	136	8
Fireclay with bands of ironstone	14	5	—	
Black bass...	2	0	—	
Coal [Fourth Coal]	2	6	155	7
Fireclay	2	2	—	
Sand-rock	3	7	—	
Grey bind with bands of ironstone	21	9	—	
Dark bind...	6	0	—	
Black bass	3	0	—	
Coal [Fifth and Sixth Coals]	4	0	196	1
Fireclay	2	0	—	
Grey sand-rock	11	10	—	
Blue bind	13	0	—	
Coal [Seventh Coal]	1	9	224	8
Fireclay	2	0	—	
Sand-rock	3	2	—	
Grey bind with bands of ironstone	26	0	255	10
[Measures containing the Eighth and Ninth Coals]	54	0	—	
Coal [Yard or Tenth Coal]	3	0	312	10

The Fifth and Sixth combined coals represent the Yard Coal of Cannock Chase, and the Yard or Tenth is equivalent to the Cinder elsewhere.

The section above (down to 255 ft. 10 in.) was measured in 1910 during repairs to the Old Engine pumping-shaft.

Brereton Collieries.—2. Brick Kiln Pit, No. 1 Shaft. Six-inch Map, Staffs. 45 S.E.

Lat. 52° 44′ 2″ N. Long. 1° 56′ 7″ W.

Height above O.D., 450 ft. Date, 1864.

Communicated by Mr. Edgar G. Sutherland, late Manager.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Top raised...	9	0	—	
Clay	9	0	—	
Rock	3	0	—	
Mixed rock	6	0	—	
Blue clod measures	16	6	—	
Bass and clod	5	9	—	
Coal 1 ft. 9 in. Pricking 0 ft. 11 in. Coal ... 1 ft. 5 in. } First Coal	4	1	53	4
Rocky ground	20	8	—	
Brown rock	3	1	—	
Parting	1	0	—	
Rock with water	12	11	—	
Blue clod ...	6	6	—	
Coal (goaf). Second Coal	3	0	100	6
Blue clod ...	13	6	—	
Dark blue metal ...	4	6	—	
Blue clod ...	2	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Coal, 9 in. Pricking, 4 in. Coal, 6 in. Pricking, 2 in. Coal, 3 in. Third Coal	2	0	122	6
Clunch	5	0	—	
Strong blue clod	30	0	—	
Dark blue clod	9	0	—	
Coal (chance)	1	8	168	2
Strong blue clunch	6	0	—	
Blue clod	5	10	—	
Strong bass	1	6	—	
Coal. Fourth Coal	2	0	183	6
Blue clod binds	15	10	—	
Hard grey rock	1	0	—	
Brown rock	2	0	—	
Strong clod	20	8	—	
Blue clod and bass	7	0	—	
Coal (goaf). Fifth Coal	3	0	233	0
Pricking (fireclay)	1	8	—	
Coal. Sixth Coal	0	4	235	0
White rock	11	0	—	
Blue clod	12	6	—	
Coal. Seventh Coal	1	7	260	1
Pricking	0	6	—	
White rock	9	0	—	
Blue strong clod	12	0	—	
Mixed brown and white rock	8	0	—	
Peldon	3	0	—	
Blue strong clod	8	8	—	
Bass	1	3	—	
Coal. Eighth Coal	4	0	306	6
Bass	1	4	—	
Coal. Ninth Coal	0	6	308	4
Pricking	0	9	—	
Strong blue clod mixed with shell [? shale]	21	0	—	
Dark blue clod mixed with shell [? shale]	4	0	—	
Clunch	2	3	—	
Dark blue clod	5	2	—	
Strong blue clod	9	0	—	
Dark blue clod	5	0	—	
Coal. Tenth or Yard Coal	3	3	358	9
Clunch	4	6	—	
Dark rock	1	6	—	
Black clod	2	0	—	
Coal, 4 in. Pricking, 9 in. Coal, 6 in. Eleventh Coal	1	7	368	4
Clunch	7	0	—	
Blue clod	12	0	—	
Coal. Twelfth or Shallow Coal	10	8	398	0
White rock	11	4	—	
Strong blue clod	32	0	—	
Strong hard clod	6	2	—	
Black slum	2	6	—	
Soft blue clod	2	0	—	
Coal. Thirteenth or Deep Coal	5	6	457	6

The Fifth Coal is said to be the Yard of Cannock Chase; the Sixth and Seventh Coals are thin, and little is known about them; the Eighth and Ninth Coals (the former of which is known as the Raggets or Ragged Jack) represent the Bass of Cannock Chase; the Tenth or Yard Coal is the Cinder elsewhere. Below the Thirteenth or Deep Coal a Fourteenth Coal has been met with, which is said to be a very regular seam. The Fifteenth Coal is the Main Coal of the Wimblebury Pits.

Brereton, Flaxley Green.—Trial-shaft for coal, one mile W.S.W. of Brereton. Six-inch Map, Staffs. 45 S.E.

Lat. 52° 44′ 23″ N. Long. 1° 56′ 35″ W.

Height above O.D., 496·5 ft. Date, 1850-1903.

Communicated by Mr. Edgar G. Sutherland, late Manager of the Brereton Collieries.

		Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Conglomerates [*Base of Pebble Beds*]		208	6	208	6
Sand-rock		59	0	—	
Blue bind		2	0	—	
Red and blue marl		15	6	—	
Sand-rock		4	0	—	
Grey rock [*Base of Hopwas Beds?*]		4	6	293	6
Blue bind and ironstone-bands [*Top of Coal Measures*]		24	6	—	
Dark shale		8	0	—	
COAL. [SEVENTH COAL of Brereton ?]		3	0	329	0
Fireclay		8	6	—	
Blue bind and ironstone		15	0	—	
Dark bind		9	0	—	
COAL. [EIGHTH COAL of Brereton ?]		4	0	365	6
Fireclay		12	0	—	
Blue bind	*Fault passed through here*	10	0	—	
COAL [SHALLOW ?]		5	6	393	0
Fireclay		5	0	—	
Blue bind		5	0	—	
Fireclay		5	0	—	
Dark bind		38	6	—	
COAL		0	6	447	0
Fireclay		20	6	—	
Dark bind		10	0	—	
COAL		1	0	478	6
Grey rock		10	0	—	
Blue bind		20	0	508	6

Brewers Old Colliery, New Invention.

From MS. in Geological Survey Office.

	Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Soil and gravel	14	5	14	5
Measures	126	3	—	
FOUR-FEET COAL	4	6	145	2
Measures	55	6	—	
HEATHEN COAL	2	6	203	2
Measures	81	6	—	
YARD COAL	3	0	287	8
Measures	38	6	—	
FIVE-FEET COAL	4	6	330	8
Measures	30	3	—	
FIRECLAY COAL	2	9	363	8
Measures	30	6	—	
SHALLOW COAL	7	0	401	2
Measures	11	0	—	
DEEP COAL	5	6	417	8

Brownhills Colliery (*No.* 3 *Plant, No.* 1 *Pit*), *Wyrley.*—Six-inch Map, Staffs. 57 N.W.

Lat. 52° 39′ 30″ N. Long. 2° 0′ 0″ W.

Communicated by Mr. J. C. Forrest.

Height above O.D., about 420 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Soil	1	0	1	0
Gravel, marl, sand [Glacial Drift]	11	6	12	6
Binds with stone	26	3	—	
Soft Coal	0	5	39	2
Fireclay	0	9	—	
Binds with peldon	35	5	—	
Coal } Benches Coal	3	0	—	
Fireclay } Benches Coal	1	0	—	
Coal } Benches Coal	2	2	81	6
Fireclay	3	6	—	
Binds with ironstone	34	0	—	
Coal. Eight-feet Coal	5	6	124	6
Fireclay	1	0	—	
Strong streaky rock	2	6	—	
Coal	1	0	129	0
Dark clod and fireclay	6	4	—	
Brown stone	1	0	—	
Coal	0	4	136	8
Binds	27	1	—	
Stone	0	2½	—	
Binds	1	6	—	
Stone	0	1½	—	
Binds	6	11	—	
Coal. Four-feet Coal	3	3	175	9
Fireclay	7	0	—	
Binds	26	3	—	
Coal	0	8	209	8
Fireclay	4	0	—	
Binds	31	0	—	
Bass and coal	1	2	—	
Fireclay and a coal 4 in.	7	8	—	
Strong rock	27	3	—	
Binds with stone	2	6	—	
Bass	0	4	—	
Coal, Heathen Coal	2	4	285	11
Fireclay	9	4	—	
Soft black batt	1	0	—	
Rock fireclay	2	6	—	
Fireclay with balls of stone	5	0	—	
Binds and peldon	14	8	—	
Rock binds and strong rock	38	6	—	
Bass	0	6	—	
Binds with stone	10	7	—	
Coal. Sulphur Coal	1	8	369	8
Fireclay and rock fireclay	4	10	—	
Binds and rock binds	29	10	—	
Coal, Yard Coal	2	10	407	2
Fireclay and rock fireclay	4	6	—	
Binds and two beds of stone	29	11	—	
Bass	0	2	—	
Coal } Bass Coal	1	6	—	
Black batt } Bass Coal	3	4	—	
Coal } Bass Coal	2	10	449	5
Fireclay	2	4	—	
Binds with stone	31	0	—	
Strong rock	10	6	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Black batt	2	6	—	
Coal	0	8	—	
Black batt	3	3	—	
Coal } Cinder Coal	3	6	—	
Soft fireclay	0	2	—	
Coal	0	9	504	1
Fireclay	2	0	—	
Rock	9	0	—	
Bass	1	7	—	
Coal. Shallow Coal	6	1	522	9
Dark fireclay	1	0	—	
Rock fireclay	3	3	—	
Rock binds	9	4	—	
Rock	2	0	—	
Peldon	1	0	—	
Binds with stone	11	8	—	
Bass	0	6	—	
Coal	1	1	552	7
Dark fireclay	4	0	—	
Binds with stone	10	3	—	
Bass	0	6	—	
Coal. Deep Coal	5	5	572	9
Black batt	0	9	—	
Fireclay with stone	7	3	—	
Black clod with stone	3	10	—	
Coal. Mealy Grey	0	6	585	1
Fireclay	2	2	—	
Rock fireclay	2	10	—	
Rock	6	0	—	
Rock binds	1	2	—	
Binds with stone	4	6	—	
Peldon	2	0	—	
Binds with stone	18	1	621	10

Cannock and Rugeley Colliery, Hednesford Pool Pits.—Six-inch Map, Staffs. 51 N.W.

Lat. 52° 42′ 43″ N. Long. 1° 59′ 16″ W.

Communicated by Col. R. S. Williamson.

Height above O.D., 575 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Gravel and soft sand, gravel [Glacial Drift]	15	1	—	
Sand rock and gravel [base of Bunter]	173	5	188	6
Mingled rock	1	0	—	
Rocky ground	0	9	—	
Red marl	1	8	—	
Dark clunch binds	15	0	—	
Old Man's Coal	6	0	212	11
Measures with thin coals	202	6	—	
Coal	3	1	—	
Batt	0	2½	—	
Coal	2	1	420	9½
Measures	24	5	—	
Coal	2	4	447	6½
Measures with thin coals	119	2½	—	
Old Park Coal	4	5	571	2
Measures with thin coals	153	5	—	
Coal	3	7	728	2
Measures with thin coals	66	10	—	
Sulphur Coal	3	4	798	4

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Measures	40	5	—	
YARD COAL	3	2½	841	11½
Measures with a thin coal	48	10½.	—	
BASS COAL	5	11	896	9
Measures	40	2	—	
CINDER COAL	4	10	941	9
Measures	25	1	—	
SHALLOW COAL	8	2½	975	0½
Measures	58	6½	—	
DEEP COAL	6	3½	1039	10½
Measures	17	2	—	
COAL	0	1	1057	1½
Measures	9	4	—	

Cannock and Rugeley Colliery Co., Cannock Wood—Wood Pits.—3½ miles E.N.E. of Cannock. Six-inch Map. Staffs. 51 N.E.

Lat. 52° 42′ 40″ N. Long. 1° 57′ 6″ W.
Height above O.D. 675 ft. Date, 1866.
Communicated by Col. R. S. Williamson, Manager.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Soil and clay	7	0	7	0
Clunch rock	10	0	—	
Sand rock	8	0	—	
Black ring	0	6	—	
Strong sand rock	10	0	—	
Light fireclay	3	0	—	
Blue binds	3	6	—	
Ironstone	0	2	—	
Black ground	2	0	—	
Light fireclay	7	10	—	
Dark rock	7	0	—	
Dark fireclay	10	0	—	
Blue binds	7	0	—	
Strong rock	10	0	—	
Blue binds	23	8	—	
Dark ground	2	8	—	
Ironstone	0	2	—	
Blue binds	4	0	—	
Ironstone	0	3	—	
Blue binds	5	0	—	
Black ring	1	6	—	
Blue binds	8	0	—	
Ironstone	0	1	—	
Blue binds	4	4	—	
COAL. OLD PARK SEAM...	3	0	138	8
Light fireclay	10	0	—	
Rock binds	15	0	—	
Strong binds	5	8	—	
Blue binds	4	8	—	
Peldon	1	1	—	
Blue binds	5	9	—	
COAL ... ... 6 in. Black ground ... 1 ft. 0 in. **COAL** (Cannel) ... 4 in.	1	10	182	8
Rock binds	6	8	—	
Blue binds	7	9	—	
Brown ironstone	1	6	—	
Black ground with ironstone	8	0	—	

	Thickness. Ft.	In.	Depth Ft.	In.
Brown ironstone	1	0	—	
Blue binds	11	9	—	
Black batt	2	10	—	
Ironstone	0	4	—	
Black ground	1	0	—	
Ironstone	0	4	—	
Batt	0	6	—	
Coal	1	8	226	0
Light fireclay	0	2	—	
Black fireclay	3	0	—	
Mingled rock	8	3	—	
Coal	0	2	237	7
Fireclay	0	11	—	
Rock binds	3	6	—	
Blue binds	1	6	—	
Grey rock	2	0	—	
Peldon	1	6	—	
White rock	1	6	—	
Rock binds	7	0	—	
Strong rock	4	0	—	
Blue binds	5	6	—	
Black batt	0	8	—	
Coal	4	3	269	11
Fireclay	10	11	—	
Black ground with ironstone	3	11	—	
Coal 8 in.	1	10	286	7
Light fireclay 10 in.				
Coal 4 in.				
Black ground	0	5	—	
Dark fireclay	1	4	—	
Dark binds	1	6	—	
Black ground with ironstone	6	2	—	
Brown ironstone	0	6	—	
Strong binds	3	2	—	
Ironstone	0	2	—	
Binds with ironstone	19	3	—	
Ironstone	0	3	—	
Black ground with ironstone	10	10	—	
Dark binds	1	3	—	
Black ground with ironstone	4	0	—	
Coal. Sulphur Coal	1	2	336	7
Soft pricking	0	8	—	
Light fireclay	9	0	—	
Dark fireclay	4	2	—	
Rock binds	4	2	—	
Shaly ground	2	8	—	
Strong rock binds with peldon	14	5	—	
Ironstone	0	3	—	
Strong rock binds with ironstone	4	4	—	
Blue binds with ironstone	3	0	—	
Dark binds with ironstone	3	2	—	
Black ground	1	0	—	
Ironstone	0	3	—	
Dark binds with ironstone	3	2	—	
Coal. Yard Seam	3	4	390	2
Pricking	1	0	—	
Fireclay with ironstone	9	0	—	
Ironstone	0	6	—	
Strong fireclay	2	9	—	
Rock binds	9	3	—	
Ironstone	0	3	—	
Dark binds	3	2	—	
Batt	0	2	—	
Coal	2	2	418	5

	Thickness. Ft.	In.	Depth. Ft.	In.
Fireclay	9	5	—	
Strong white rock	9	9	—	
Rock binds	2	8	—	
Dark clod	1	0	—	
COAL. BASS COAL	5	10	447	1
Pricking	1	0	—	
Rock binds	18	9	—	
Shell-bed	5	0	—	
COAL	0	7	472	5
Shaly ground	6	0	—	
Black ground	0	10	—	
Ironstone	0	2	—	
Blue binds	2	9	—	
Ironstone	0	2	—	
Black ground	0	7	—	
Ironstone	0	2	—	
Black ground	2	0	—	
Batt	0	2	—	
COAL ... 3 ft. 6 in.	5	11	491	2
Pricking ... 8 in.				
COAL ... 1 ft. 9 in.				
Black ground	0	9	—	
Strong fireclay	12	0	—	
Rock binds	12	2	—	
Dark binds	12	10	—	
Rock binds	6	0	—	
Rock	1	4	—	
Black bass with ironstone	4	0	—	
COAL. SHALLOW SEAM	9	3	549	6
Black ground	5	11	—	
Strong fireclay	5	3	—	
Strong rock binds	9	0	—	
Peldon	2	9	—	
Strong rock binds	5	3	—	
Rock binds with ironstone	12	7	—	
Strong blue binds with ironstone	12	0	—	
COAL. DEEP SEAM	7	0	609	3
Blue binds	9	0	—	
Fireclay	10	3	—	
Ironstone	0	3	—	
Black ground	1	10	—	
COAL	1	4	631	11
Fireclay	1	1	633	0

The section relates to the Upcast (Ventilation) Shaft.

Cannock and Rugeley Colliery Co., Wimblebury Pits, two miles N.E. of Cannock. Six-inch Map, Staffs. 51 N.E.

Lat. 52° 42′ 10″ N. Long. 1° 58′ 47″ W.

Height above O.D., 575 ft. Date, 1872 or 1873.

Communicated by Col. R. S. Williamson, Manager.

	Thickness. Ft.	In.	Depth. Ft.	In.
Made ground	9	0	—	
Soil	2	0	—	
Clay	13	0	—	
White fireclay	6	8	—	
Brown rock yielding water	3	6	—	
White binds mingled with ironstone	15	6	—	
Blue binds	3	0	—	

	Thickness		Depth	
	Ft.	In.	Ft.	In.
Coal. Old Man's Seam; yielding water	7	6	60	2
Light fireclay	18	6	—	
Coal	3	6	82	2
Black fireclay	3	6	—	
Ironstone balls	0	4	—	
Black batt	2	4	—	
Bands of ironstone	0	6	—	
Dark fireclay	2	6	—	
Coal, slummy	2	4	93	8
White fireclay	12	0	—	
Dark slummy ground, and water	6	0	—	
Coal	1	0	112	8
Dark fireclay	2	0	—	
Black ground mingled with ironstone	4	4	—	
Strong black clod	7	0	—	
Coal with many partings; water	6	3	132	3
Strong batt	2	3	—	
Coal, hard brazzly; yields water	6	0	140	6
Strong black ground	3	6	—	
Light fireclay	3	8	—	
Coal, brazzly	2	0	149	8
White ground mingled with ironstone	18	0	—	
Blue bind clod	9	0	—	
Strong peldon	8	6	—	
Rock binds; water	13	6	—	
Binds	12	0	—	
Dark binds	19	0	—	
Black binds	1	0	—	
Coal	7	0	237	8
Slums	3	0	—	
Black bass	6	9	—	
Black ground	2	9	—	
Fireclay	2	0	—	
Black ground	2	6	—	
Coal	0	9	255	5
Fireclay	1	3	—	
Blue binds	4	0	—	
Rock binds	2	0	—	
Binds	5	0	—	
Rock	1	6	—	
Binds	11	0	—	
Rock binds	5	0	—	
Peldon	2	9	—	
Binds	9	6	—	
Rock binds	5	0	—	
Binds	12	0	—	
Rock binds	1	0	—	
Binds	3	0	—	
Coal. Brooch Seam	2	9	321	2
Fireclay	4	0	—	
Blue binds	7	6	—	
Clunch	4	0	—	
Binds	4	6	—	
Rock binds	2	0	—	
Binds	9	0	—	
Rock	5	4	—	
Binds	16	0	—	
Coal	4	2	377	8
Fireclay	6	0	—	
Blue binds	9	6	—	
Rock binds	3	0	—	
Binds	4	6	—	
Rock binds	7	0	—	
Binds and rock binds	8	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
White rock	5	0	—	
Blue binds	8	0	—	
Bastard fireclay (top of fault)	6	0	—	
Dark clod	8	0	—	
Rock binds	3	0	—	
Coal. Old Park Seam	6	0	451	8
Fireclay	4	0	—	
Mixed ground, etc.	30	0	—	
Wild ground, binds and sand rock	12	0	—	
Light shale, faulty	30	0	—	
Soft binds and fireclay	18	0	—	
Coal (one side of shaft only)	9	0	554	8
Strong mingled ground	57	0	—	
Blue binds	18	0	—	
Mingled ground	33	0	—	
Strong blue ground	18	0	—	
Coal. Yard Seam	4	0	684	8
Coal and blue ground	2	0	—	
Blue ground and ironstone measures	16	6	—	
Dark shale	1	6	—	
Strong blue clod	15	0	—	
Coal. Bass Seam	7	6	727	2
Fireclay	0	6	—	
Fireclay with balls of ironstone	4	0	—	
Binds	14	0	—	
Dark shale with fossil ferns	8	0	—	
Strong clod with ironstone	2	0	—	
Dark clod	2	0	—	
Coal. Cinder Seam	4	0	761	8
Strong dark fireclay	3	0	—	
Fireclay with balls of ironstone	4	0	—	
Strong blue clod	12	0	—	
Very strong blue binds	7	0	—	
Dark ground	2	0	—	
Strong blue binds	8	6	—	
Dark ground	2	0	—	
Coal. Shallow Seam	8	6	808	8
Fireclay	3	0	—	
Strong white rock	8	4	—	
Very strong rock binds	13	8	—	
Peldon	5	6	—	
Rock	2	6	—	
Blue ground	25	6	—	
Dark ground	1	6	—	
Coal. Deep Seam	6	6	875	2
Fireclay	6	0	—	
Dark binds	12	0	—	
Coal	1	0	894	2
Fireclay	1	6	—	
Strong white rock	11	6	—	
Blue binds	2	0	—	
Blue binds with long snaky pieces of ironstone	7	0	—	
Light blue binds with beds of ironstone	5	0	—	
Light binds with ironstone beds	4	0	—	
Dark binds	5	0	—	
Ironstone cakes	0	2	—	
Dark binds }	1	3	—	
Ironstone }	0	2	—	
Dark binds } Diamonds Ironstone	1	0	—	
Ironstone }	0	3	—	
Dark binds }	1	4	934	4
Coal mixed with binds	1	6	935	10
Strong rocky fireclay	4	2	—	
Dark binds with shells and fossils	4	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Ironstone	0	2	—	
Clunch binds	0	6	—	
Dark binds	2	3	—	
Ironstone beds	0	1	—	
Peldon	1	3	—	
Rock binds	1	6	—	
Strong white rock bed	0	3	—	
Rock binds	13	0	—	
Light blue binds with thin bands of ironstone	7	6	—	
Light binds with ironstone	12	11	—	
Loam	0	4	—	
Black bass	0	5	—	
Coal [Main Seam]	4	4	988	6
Light fireclay	3	4	—	
Fireclay rock, very hard	3	0	—	
Hard purple reddish rock	4	0	—	
Very hard white rock	3	0	—	
Rock mingled with red	4	4	—	
Light blue binds with red balls of ironstone...	4	0	—	
Reddish binds with balls of ironstone ...	1	0	—	
Variegated rock	1	6	—	
Purple strong binds with balls of ironstone ...	27	7	1040	3

The section relates to the eastern of the two shafts.

Cannock Chase Colliery, No. 9 *Pit.*—Six-inch Map, Staffs. 51 S.W.

Lat. 52° 42′ 0″. Long. 1° 59′ 10″ W.
Communicated by Mr. S. F. Sopwith.
Height above O.D., about 560 ft.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Gravel and red clay [Glacial Drift]		12	0	12	0
Clunch and bind		20	0	—	
Coal. Old Mans Coal		7	0	39	0
Measures with thin coals		165	1	—	
Coal. Brooch Coal		4	2	208	3
Measures		86	8	—	
Coal	Five Feet Coal	3	0	—	
Parting		0	6	—	
Coal		1	6	299	11
Measures		43	9	—	
Coal. Four Feet Coal		4	0	347	8
Measures with thin coals		107	10	—	
Coal. Old Park Coal		4	10	460	4
Measures with thin coals		117	9	—	
Coal	not named	3	0	—	
Blue clod		2	8	—	
Coal		3	2	586	11
Measures with thin coals		134	3	—	
Coal. Yard Coal		3	2	724	4
Measures		42	4	—	
Coal. Bass Coal		7	0	773	8
Measures with thin coals		25	5	—	
Coal. Cinder Coal		3	10	802	11
Measures		45	0	—	
Coal. Shallow Coal		8	0	855	11
Measures		56	0	—	
Coal. Deep Coal		6	6	918	5
Measures with thin coal		31	6	949	11

East Cannock Colliery, Hednesford, No. 2 Shaft.—Six-inch Map, Staffs. 51 S.W.

Lat. 52° 42′ 5″. Long. 2° 0′ 8″ W.

Scaled from a section supplied by Mr. J. W. Morris.

Height above O.D., 513 ft.

		Thickness. Ft.	In.	Depth. Ft.	In.
Sandy clay and sand		66	0	66	0
Red brown and purple marls (Etruria Marls)		63	0	129	0
Measures		215	4	—	
Coal	Old Man's Coal	2	0	—	
Parting		0	2	—	
Coal		4	0	—	
Fireclay		1	6	—	
Coal, brassy		2	0	354	0
Measures		158	3	—	
Brooch Coal		3	9	516	0
Measures		69	8	—	
Coal	Five Feet Coal	2	6	—	
Parting		0	7	—	
Coal		2	3	591	0
Measures		39	0	—	
Four Feet Coal		3	0	633	0
Measures		93	3	—	
Old Park Coal (Main Hard of West Cannock)		5	9	732	0
Measures		273	0	—	
Yard Coal		3	0	1008	0
Measures		36	6	—	
Coal	Bass Coal	1	0	—	
Fireclay		2	0	—	
Coal		5	6	1053	0
Measures		42	0	—	
Cinder Coal		—		1095	0
Measures		22	0	—	
Shallow Coal		8	0	1125	0
Measures		29	4	—	
Deep Coal		6	8	1161	0

Great Wyrley Colliery, Cheslyn Hay.—Six-inch Map, Staffs. 57 N.W.

Lat. 52° 39′ 33″. Long. 2° 1′ 12″ W.

Communicated by Mr. Isaiah Hill.

Height above O.D., about 470 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Sand, clay and gravel [Glacial]	25	0	25	0
Charles Coal	2	6	27	6
Measures	83	0	—	
Brooch Coal	3	6	114	0
Measures	1	5	—	
Bench Coal	2	4	117	9
Measures	39	9	—	
Eight-feet Coal (gob) with partings	8	6	166	0
Measures	44	0	—	
Four-feet Coal	3	10	213	10
Measures	89	7	—	
Heathen Coal	2	3	305	8
Measures	80	2	—	
Sulphur Coal	1	3	387	1
Measures	42	0	—	

				Thickness.		Depth.	
				Ft.	In.	Ft.	In.
Yard Coal				2	6	431	7
Measures				37	8	—	
Five-feet Coal				3	1	472	4
Measures				39	4	—	
Cinder or Fireclay Coal	Roof coal	1	2	9	1	520	9
	Batt	2	10				
	Coal	3	11				
	Clay	0	5				
	Coal	0	9				
Measures				11	1	—	
Shallow Coal				5	9	537	7
Measures with thin coal				50	11	—	
Deep Coal				4	11	593	5

Hilton Colliery, No. 1 Shaft.—Six-inch Map, Staffs. 57 S.W.

From a plan deposited in the Home Office.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
	Soil	1	0	—	
	Clay and sand	46	0	47	0
	Binds	10	0	—	
Eight Feet	Coal with two thin partings	7	0	—	
	Parting	1	0	—	
	Coal	3	0	—	
	Parting	1	4	—	
	Coal	0	10	70	2
	Measures with two thin coal seams	53	10	—	
Four-feet Coal		4	6	128	6
	Measures	53	6	—	
Heathen Coal		2	0	184	0
	Measures	59	0	—	
Stinking Coal		2	0	245	0
	Measures	48	0	—	
Yard Coal		2	6	295	6
	Measures	27	6	—	
Five Feet.	Coal with a parting	5	0	328	0
	Measures	47	0	—	
Fire Clay.	Coal with a parting	6	6	381	6
	Measures	37	6	—	
Shallow Coal		7	0	426	0
	Measures	23	0	—	
Deep Coal		7	0	456	0

Newfield Colliery, Bloxwich.—Six-inch Map, Staffs. 63 N.W.

From a plan deposited in the Home Office.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Soil	3	0	—	
Clay and gravel	12	0	15	0
Coal	1	0	16	0
Peldon	1	3	—	
Fireclay	6	6	—	
White sandstone	46	3	—	
Peldon	0	3	—	
Fireclay-rock	11	3	—	
Yard Coal	3	0	84	6

West Cannock Colliery, Hednesford, No. 1 *Shaft.*—Six-inch Map, Staffs. 51 N.W.

Lat. 52° 42′ 50″. Long. 2° 0′ 40″ W.

Communicated by Mr. J. Smithurst.

Height above O.D., about 600 ft.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Surface soil and measures	51	5	51	5
Coal	1	8	53	1
Measures	26	10	—	
Coal	2	4	82	3
Measures	22	0	—	
Coal, Brooch Coal	3	11	108	2
Measures	113	4	—	
Coal, Five-feet Coal	5	3	226	9
Measures	36	0	—	
Coal, Four-feet Coal	3	6	266	3
Measures	100	11	—	
Coal, Old Park (Main Hard) Coal	5	0	372	2
Measures	158	0	—	
Coal, Ragged Jack Coal	4	2	534	4
Measures	16	5	—	
Coal	1	4	552	1
Measures	61	8	—	
Coal	2	1	615	10
Measures	7	0	—	
Coal	2	3	625	1
Measures	33	9	—	
Coal, Yard Coal	2	10	661	8
Measures	31	11	—	
Coal	1	3	694	10
Measures	31	0	—	
Coal, Bass Coal	3	2	729	0
Measures	5	10	—	
Coal	2	2	737	0
Measures	59	0	—	
Coal, Cinder Coal	3	10	799	10
Measures	2	8	—	
Coal	1	4	803	10
Measures	5	2	—	
Coal, Shallow Coal	9	3	818	3
Measures	25	5	—	
Coal	2	2	845	10
Measures	51	7	—	
Coal, Deep Coal	4	4	901	9

(b) North Warwickshire Coalfield.

Amington and Glascote Colliery Company.

(1) *Amington Colliery* (Plate at end of volume).—Six-inch Map, Warwick. 2 S.E.

Lat. 52° 37′ 45″. Long. 1° 38′ 35″ W.

Communicated by Mr. F. A. Grayston.

Height above O.D., 293 ft.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Made up ground	15	0	—	
Clay	3	9	—	
Marl	4	6	23	3
Sandstone	4	6	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Light fireclay	0	10	—	
Marl	8	8	37	3
Light blue bind	1	4	—	
Marl	13	3	51	10
Black ring	0	5	52	3
Fireclay	2	0	—	
Fireclay containing ironstone	1	6	—	
Coal	0	4	56	1
Fireclay	2	0	—	
Bind	6	6	—	
Marl	2	2	66	9
Fireclay and coal parting	4	0	—	
Dark binds with cakes of ironstone	1	0	—	
Light blue binds with cakes of ironstone	10	7	—	
Bind	2	0	—	
Black parting	0	9	—	
Fireclay	3	0	—	
Light blue bind	4	9	—	
Rock binds	2	0	—	
Bind with balls of rock parting	7	8	—	
Ironstone	1	2	—	
Rock bind	3	0	—	
Rock	0	10	—	
Rock bind	1	0	—	
Rock	0	4	—	
Rock bind	1	3	—	
Rock	0	4	—	
Strong brown sandstone	9	0	—	
Rock bind	0	6	—	
Strong sandstone	6	0	—	
Red marl	2	0	127	11
Very strong marl	2	3	130	2
Fireclay	1	0	—	
Coal	0	5	131	7
Fireclay	5	0	—	
Coal	0	6	137	1
Tough fireclay	1	6	—	
Fireclay with ironstone	4	6	—	
Marl [Typical Etruria Marl. Base of the Group]	12	6	155	7
Binds with balls of rock	3	0	—	
Rock and bind	5	11	—	
Sandstone	3	6	—	
Coal	0	9	168	9
Batt	0	6	—	
Fireclay, very good	4	0	—	
Fireclay and ironstone	1	0	—	
Very strong fireclay	3	0	177	3
Rock binds	3	6	—	
Ironstone measures	1	2	—	
Blue binds	1	0	—	
Dark bind with rock and coal	9	6	—	
Coal	0	4	192	9
Rock bind	3	0	—	
Rock	3	0	—	
Ironstone	0	4	—	
Dark sherry rock	4	6	—	
Dark rock bind	6	4	—	
Dark grey rock	8	6	—	
Bind	1	6	—	
Batt	0	6	—	
Black ironstone	0	9	—	
Coal	0	3	221	5
Parting	0	1	—	
Fireclay with ironstone balls	4	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Marl	2	0	—	
Light rock binds	2	0	—	
Grey rock	10	6	—	
Blue binds	5	6	—	
Strong grey rock	3	6	—	
Blue bind with ironstone balls	15	0	—	
Very strong grey rock	2	0	—	
Strong blue bind	21	0	—	
Batt	0	4	—	
COAL	1	0	288	4
Fireclay	2	0	—	
COAL	1	3	291	7
Clunch	2	0	—	
Dark bind with small nodules of ironstone	12	0	—	
Dark binds, without stone, but with black sheds	13	0	—	
Strong dark bind	34	0	—	
Sandstone	4	8	—	
Rock bind	4	1	—	
Sandstone rock	1	4	—	
Rock binds	5	9	—	
Batt	0	2	—	
COAL	2	9	371	4
Pricking	0	3	—	
Clay containing iron	1	3	—	
,, checkles	2	6	—	
Rock with dark sheds	7	6	—	
Rock binds	8	2	—	
Blue bind	0	4	—	
COAL	1	8	393	0
Pricking	0	1	—	
Dark batt	0	9	—	
Very strong rocky clay with checklestones	5	0	—	
Rock	5	9	—	
Rock binds	4	0	—	
Bind containing stone	5	0	—	
Shale	0	4	—	
Dark clunch	0	9	—	
Bind	1	0	—	
Ironstone	0	3	—	
Bind	7	9	—	
COAL	0	2	423	10
Batt	3	6	—	
Slum	0	9	—	
Batt	0	9	—	
Bind	3	6	—	
Rock	3	0	—	
Rock binds	6	0	—	
Rock	2	0	—	
Bind	0	4	—	
Ironstone	0	2½	—	
Bind	0	7	—	
Ironstone	0	2½	—	
Bind containing stone	4	0	—	
Batt	0	2	—	
COAL	2	0	450	10
Fireclay	1	0	—	
Very rocky clay	7	0	—	
Bind	6	0	—	
Clunch	0	9	—	
Ironstone	0	1½	—	
Batt	0	2	—	
Dark bind	3	3	—	
Ironstone	0	2	—	
Bind	8	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In
Ironstone	0	1½	—	
Bind	4	0	—	
Batt	0	4	—	
COAL	0	9	482	6
Rock bind	5	3	—	
Bind with 1 in. ironstone	4	7	—	
Rock bind with 2½ in. ironstone	4	5½	—	
Batt	3	0	—	
COAL	2	9	502	6½
Fireclay	0	6	—	
Bind	1	3	—	
Rock	3	9	—	
Bind	1	0	—	
Rock	2	10	—	
Bind	1	6	—	
Ironstone 1½ in. Bind 1 ft.	1	1½	—	
COAL	0	6	515	0
Fireclay	0	4	—	
Bind with stone in thin beds and balls ...	8	6	—	
Rock bind	1	6	—	
Rock very hard	3	3	—	
Rock bind	7	6	—	
Bind	10	6	—	
COAL (fair quality no value at present) ...	2	1	548	8
Dark fireclay	1	2	—	
Strong clunch with ironstone	8	8	—	
Strong clunch	2	3	—	
Dark clod with ironstone	4	9½	—	
Pricking	0	3	—	
COAL. SMITHY COAL	2	3	568	0½
Batt	0	8	—	
Strong bind	2	0	—	
Strong rock bind	10	0	—	
Dark bind	0	10	—	
Sandstone rock	8	0	—	
Rock bind	1	10	—	
Binds with ironstone in thin beds	14	8	—	
Dark blue bind with thin "sheds" of ironstone	21	6	—	
COAL. THIN COAL	2	4	629	10½
Fireclay	0	8	—	
COAL. SEVEN FEET	5	5	635	11½
Fireclay, dark	5	0	—	
Fireclay, light	1	0	—	
Fireclay, very strong	3	0	—	
Rock bind	16	0	—	
COAL	0	6	661	5½
Fireclay, strong in middle, coal sheds at base	7	9	—	
COAL	0	7	669	9½
Fireclay	3	6	—	
Bind with ironstone	10	0	—	
Rock, probably trappean rock	1	6	—	
Bind	7	2	—	
Ironstone 2 in. Bind 2 ft. 9 in.	2	11	—	
Black batt	0	11	—	
COAL	2	8	698	5½
Batt	0	8	—	
Fireclay with coal partings	1	9	—	
Dark bind with ironstone	3	9	—	
Bind	1	9	—	
Grey rock	1	6	—	
Bind	0	6	—	
Rock	1	6	—	
Rock binds	13	10	—	
Black batt with two thin beds of ironstone ...	2	4½	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
COAL	2	11	729	0
Clay	1	1	—	
COAL	1	11	732	0
Clay	0	7	—	
COAL	1	9	734	4
Fireclay with checkles	5	0	—	
Bind ,, ,,	3	6	—	
Fireclay with Ironstone and checkles	3	9	—	
COAL. DOUBLE COAL	4	3	750	10
Fireclay	1	2	—	
CANNEL COAL	0	9	752	9
Batt	0	2	—	
Rock binds	3	3	—	
Rock	5	3	—	
Binds	24	6	—	
Batt 6 in. Batt and COAL mixture 1 ft. 5 in.	1	11	—	
COAL. BENCH COAL	5	0	792	10
Clunch with checkles	13	4	—	
Fireclay very strong	7	6	—	
Strong blue binds with ironstone balls	6	0	819	8

The beds down to 155 ft. belong to the Etruria Marl Group, but typical marl occurs at intervals only, the intervening beds being indistinguishable from the grey Coal Measures below. Further east and south-east the typical marl almost entirely disappears, and there is no means of distinguishing between the two groups.

(2) *Glascote Colliery* (Plate at end of Volume).—Six-inch Map, Warwick. 2 S.E.

Lat. 52° 37′ 35″. Long. 1° 39′ 44″.

Communicated by Mr. S. Spruce when the shaft was widened.
Height above O.D., about 360 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Raised ground	15	9	—	
Yellow clay	15	6	—	
COAL	2	1	33	4
Fireclay and dark clunch	9	11	—	
Blue bind with ironstone	9	1	—	
COAL	0	6	52	10
Fireclay	9	1	—	
Blue bind and sandstone rock	8	0	—	
Sandstone rock	10	0	—	
Shale	2	6	—	
Bind with ironstone	32	0	—	
COAL	2	0	116	5
Dark fireclay with coal partings	4	2	—	
Bind with ironstone	26	9	—	
Coal parting	0	1	147	5
Layers of blue bind and grey rock	23	0	—	
Rock	8	0	—	
Blue bind	11	9	—	
Batt	0	4	—	
COAL	3	6	194	0
Rock, fireclay with nodules of ironstone	4	3	—	
Rocky bind	12	0	—	
COAL	1	6	211	9
Fireclay, 3½, bind 3½, rocky bind 2½	9	6	—	
Grey rock	8	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Rocky bind and blue bind	19	8	—	
Batt	0	6	—	
COAL	1	10	251	3
Slum	0	6	—	
Rocky binds	7	8	—	
Rocky bind 3¾, peldon 2½, rocky bind 3¾	10	0	—	
Ironstone	0	2½	—	
Grey rock and bind	5	10	—	
COAL	2	0	277	5½
Fireclay	2	4	—	
Blue bind	13	9	—	
Black batt	2	11½	—	
Ironstone	0	2½	—	
Rocky bind	15	0	—	
Ironstone	0	2½	—	
Bind	4	10	—	
Batt	0	4	—	
COAL	1	9	318	10
Rocky bind	9	9	—	
Ironstone	0	2½	—	
Batt	0	9	—	
Ironstone	0	2½	—	
Batt	3	0	—	
COAL	4	0	336	9
Rocky bind	9	6	—	
Ironstone	0	2½	—	
Rocky bind and blue bind	6	8	—	
Sandstone rock	7	4	—	
Rocky bind	3	8	—	
COAL	2	0	366	1½
Fireclay 1, rock 2⅓, clunch 10½ ft.	13	11	—	
Ironstone	0	4	—	
Black batt ⅓, pricking ½, clod 2½ ft.	3	4	—	
COAL, Smithy	2	3	385	11½
Pricking 2 in., bind 10 in.	1	0	—	
Sandstone rock 7, peldon 6½ ft.	13	6	—	
Rocky bind	6	3	—	
Rocky bind with ironstone	5	3	—	
Rocky bind	10	10	—	
Blue bind with ironstone	2	2	—	
Clod	4	0	—	
Ironstone	0	2½	—	
Rock	0	7	—	
Ironstone	0	4	—	
Clod	0	2	—	
Ironstone	0	1½	—	
Blue bind	15	0	—	
COAL [THIN COAL]	2	1	447	5½
Fireclay	3	0	—	
COAL, SEVEN-FEET Coal	5	11	456	4½
Fireclay	5	11	—	
Rocky bind	17	6	—	
COAL	2	2	481	11½
Fireclay	3	2	—	
Rocky bind	19	2	—	
Batt	2	3	—	
COAL	2	0	508	6½
Layers of rock, slum and fireclay	11	3	—	
Ironstone	0	1½	—	
Rocky bind	13	0	—	
Rock	23	0		
Rocky bind	6	0	—	
Blue bind and black batt	3	1	—	
COAL	4	0	569	0

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Fireclay and black batt ...	2	6	—	
COAL ...	1	3	572	9
Clunch ...	3	0	—	
COAL ...	3	0	578	9
Fireclay ...	0	11	—	
COAL, Deep [Double] Coal ...	5	0	584	8
Fireclay 1ft., batt 3 in. ...	1	3	—	
COAL ...	0	7	586	6
Batt ...	0	4	—	
Rocky bind with large balls of ironstone ...	10	0	—	
Bind with ironstone ...	1	4	—	
Blue bind ...	14	0	—	
Batt and sloam ...	5	0	—	
COAL, BENCH COAL ...	6	0	623	2

Birch Coppice Colliery, No. 1 *Cockspur Pit* (Plate at end of Volume).—One-inch Map (N.S.) 155 (on western margin). Six-inch Warwick. 5 N.E.

Lat. 52° 36′ 48″. Long. 1° 37′ 50″ W.

Communicated by Mr. T. W. Allen for Messrs. Morris & Shaw.

Height above O.D., about 310 ft.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Halesowen Sandstones	Soil and marl ...	4	0	—	
	Broken sand-rock ...	3	0	—	
	Brown rock ...	64	0	71	0
	Blue stone ...	3	0	—	
	Strong blue marl ...	21	0	—	
	Blue ragstone ...	2	0	—	
	White sandstone ...	57	0	154	0
	White ragstone ...	2	3	—	
	Blue bind ...	4	0	—	
	Brown sandstone ...	50	0	210	3
Strong bind with gravel ...		53	9	—	
Strong fireclay ...		3	0	—	
Dark stone ...		1	0	—	
Blue bind ...		7	8	—	
Rocky bind ...		3	0	—	
Blue bind ...		14	0	—	
Black shale ...		0	8	—	
Dark clunch ...		1	6	—	
Light fireclay ...		1	6	—	
Rocky bind [Base of Etruria Marl ?] ...		7	2	—	
Grey rock ...		16	1	—	
Rocky bind ...		1	6	—	
COAL ...		0	3	321	4
Rocky bind ...		1	3	—	
Grey rock ...		16	0	—	
Rocky bind ...		3	0	—	
Brown peldon ...		6	0	—	
Rocky bind ...		6	0	—	
Blue bind ...		8	0	—	
Clunch and fireclay ...		2	6	—	
Grey rock ...		11	0	—	
Red marl [resembling Etruria Marl] ...		5	0	380	1
Dark bind... ...		7	0	—	
Dark rock, strong ...		1	2	—	
COAL ...		0	4	388	7
Clunch and bind ...		1	10	—	
COAL ...		0	8	391	1
Clunch and fireclay ...		2	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Fireclay	1	0	—	
Rocky bind	1	0	—	
Light peldon	2	0	—	
COAL	0	4	397	5
Fireclay	0	8	—	
Clunch	9	0	—	
Black batt	2	0	—	
COAL	0	9	409	10
Clunch	3	3	—	
Fireclay	3	0	—	
Blue bind	6	0	—	
Fireclay	2	0	—	
Rocky bind	6	0	—	
Dark rock	3	0	—	
Dark bind	4	0	—	
COAL	0	5	437	6
Marl and fireclay	10	7	—	
Light peldon	3	0	—	
Black batt mixed with coal	3	0	—	
Grey rock	9	0	—	
Black batt	0	6	—	
Fireclay	4	0	—	
Black batt	1	0	—	
COAL	2	0	470	7
Clunch	3	9	—	
Black batt	2	3	—	
Blue bind	1	6	—	
Grey rock	12	0	—	
Blue bind and ironstone balls	21	6	—	
COAL. [FOUR-FOOT COAL]	2	3	513	10
Black batt	1	6	—	
Batt and coal	2	0	—	
Clunch	3	0	—	
Black batt	1	6	—	
Blue bind	19	3	—	
Dark bind	5	0	—	
COAL. [THIN RIDER COAL]	3	6	549	7
Dark pricking	0	4	—	
Clunch and ironstone balls	7	0	—	
Black batt	1	2	558	1
Batt, mixed with coal	6	0	564	1
Fireclay	3	0	—	
Rocky bind	3	0	—	
Blue bind	16	0	—	
COAL. RIDER not worked here	3	2	589	3
Dark bind and ironstone balls	3	10	—	
COAL. [BARE COAL]	2	6	595	7
Clunch and fireclay	6	0	—	
Skerry rock	16	0	—	
Blue bind	4	0	—	
Black batt	0	6	—	
COAL	1	0	623	1
Clunch and ironstone balls	8	0	—	
Dark bind and ironstone balls	3	6	—	
Clunchy bind and ironstone balls	9	0	—	
COAL	0	3	643	10
Blue bind	20	3	—	
Batt and COAL	1	4	665	5
Rocky clunch	6	0	—	
Rocky bind and ironstone balls	3	0	—	
Dark bind	3	0	—	
Clunch and coal mixed	16	6	—	
Batt	7	0	—	
Very strong clunch	3	0	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Blue bind	6	0	—	
Grey rock	13	6	—	
Rocky bind	3	6	—	
COAL. SMITHY COAL	2	3	729	2
Clunch and ironstone balls	3	0	—	
Grey rock	1	0	—	
Dark binds	9	0	—	
Ironstone 2 in.; sooty batt 3 in.; ironstone 4 in.	0	9	—	
Dun-coloured bind and ironstone nodules	2	9	—	
Coal	1	9	747	5
Fireclay	3	6	—	
Grey rock	2	0	—	
Very strong rocky bind	5	7	—	
Grey rock	1	0	—	
Rocky bind and ironstone nodules	7	0	—	
Blue bind	2	9	—	
Dark rock, hard	2	10	—	
Blue bind	9	0	—	
Black batt	0	2	—	
Cank and ironstone balls	1	3	—	
Dark bind	9	6	—	
COAL. [THIN COAL]	2	3	794	3
Clunch and bind	3	6	—	
COAL. [SEVEN FEET COAL]	6	0	803	9

For notes on this section, see p. 30.

Birch Coppice Colliery, No. 2. Hall End Shaft (Plate at end of Volume).—One-inch Map (N.S.) 155. Six-inch Map, Warwick. 5 N.E.

Lat. 52° 35′ 55″. Long. 1° 37′ 36″ W.

Abstract of a section published in 'The Country between Atherstone and Charnwood Forest,' *Mem. Geol. Survey*, 1900, pp. 55-58.

Height above O.D., 342 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Rise of ground and soil	6	10	—	
Sandstone	12	8	—	
Sandstones and clays, etc.	26	6	—	
Mainly sandstone	57	0	103	0
Clays, etc.	12	7	—	
Grey sandstone	60	0	175	7
Cank and strong rocky bind	27	0	—	
Strong grey rock [Base of Halesowen Group]	15	6	218	1
Red marl and fireclay, good	5	0	223	1
Binds and fireclay	37	4	—	
Red marl, good	15	0	275	5
Binds and fireclay	28	8	—	
COAL, No. 1	0	3	304	4
Fireclay	0	3	—	
Red marl, good. [Base of Etruria Marl]	6	0	310	7
Rock and fireclay	32	7	—	
Light blue rock, very strong	41	5	384	7
Rocky bind and grey rock	18	7	—	
Very rough light rock mixed	6	0	409	2
Strong grey rock	9	3	418	5
Red fireclay	2	3	420	8
Measures	20	5	441	1
COAL, No. 2	2	2½	443	3½

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Measures ...	12	5½	—	
Coal, No. 3	1	2	456	11
Measures ...	43	2	—	
Coal. No. 4	0	6	500	7
Measures ...	16	2	—	
Four Feet Coal	4	4	521	1
Measures ...	42	1	—	
Coal, soft dicey ...	4	4	567	6
Measures ...	28	9	—	
Thin Rider Coal	2	9	599	0
Measures ...	26	6	—	
Rider Coal (Seam worked)	4	4	629	10
Pricking ...	0	5	—	
Bare Coal	2	10	633	1
Measures ...	9	4	—	
Coal and dark clunch mixed ...	7	10	650	3
Measures ...	23	3	—	
Coal, inferior	2	0	675	6
Measures ...	18	11	—	
Coal, good	1	4	695	9
Measures ...	10	9	—	
Coal and black batt	4	3	710	9
Measures ...	38	0½	—	
Smithy Coal	2	3	751	0½
Measures ...	16	0	—	
Coal	2	0	769	0½
Measures ...	3	6	—	
Coal	0	4	772	10½
Measures ...	36	6	—	
Thin Coal	2	3	811	7½
Soft bind ...	2	9	—	
Seven Feet Coal	6	0	820	4½

For notes on the section given above see p. 36.

Birch Coppice Colliery, No. 3 *Shaft, Wood End* (Plate at end of Volume[1]).—One-inch Map (New Series), 155. Six-inch Warwick. 6 S.E.

Lat. 52° 34′ 52″. Long. 1° 37′ 50″ W.

Height above O.D., 440 ft.

Sunk in 1911-14, and communicated by Mr. T. W. Allen.

Notes in square brackets have been added to the original account after examination of the specimens.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Made ground ...	23	0	23	0
Red sandstone [red brown, fine-grained, rather flaggy and calcareous] ...	4	0	—	
Red marl [green spots ; calcareous] ...	5	5	—	
Red marl with boulders and thin layers of sandstone-rock [as above] ...	37	11	—	
Calcareous sandstone [hard white. Base of Keele Group] ...	3	10	74	2
Red and blue marl [greenish ; small calcareous concretions] ...	24	1	—	
Grey sandstone [not calcareous ; white, green and black grains] ...	11	4	—	
Red and blue marl [numerous blebs of limestone]	1	4	—	
Grey sandstone [as above, but calcareous] ...	2	5	—	

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[1] In the Plate the base of the Halesowen group is shown at a depth of 317 ft. 10 in. by error.

	Thickness. Ft.	In.	Depth. Ft.	In.
Brown marl [green-mottled; calcareous]	15	8	—	
Red marl	9	0	—	
Blue marl [greenish; many blebs of limestone]	5	0	—	
Red and blue marl [similar to bed above]	4	0	—	
Red marl [pellets of limestone]	10	4	—	
Blue marl [greenish-grey, calcareous; pellets of limestone]	6	0	—	
Red marl [calcareous; green spots]	3	8	—	
Grey marl [mottled, calcareous]	1	6	—	
Grey and brown marl [calcareous; pellets of limestone]	11	6	—	
Conglomerate [grey marl with pellets of limestone up to ¼ inch diameter]	4	6	—	
Grey sandstone [calcareous; pink, black and green grains; local patches of green marl]	3	2	—	
Grey marl [greenish with patches of sandstone]	1	6	—	
Grey and red marl [calcareous; dull brown with green stripes]	8	1	—	
Strong grey marl	1	6	—	
Brown and grey marl [green spots]	6	3	—	
Red marl [pellets of limestone]	5	0	—	
Brown and grey marl [green spots]	5	0	—	
Strong grey marl [dark, not calcareous]	7	0	—	
Grey sandstone	0	4	—	
Strong grey marl [slickenside]	9	2	—	
Strong blue marl [sandy marl]	2	9	—	
Fine grey sandstone [veined with calcite]	6	6	—	
Red and grey marl [slickenside]	8	3	—	
Black parting [coaly]	0	1	—	
Dark bind	4	8	—	
Grey sandstone	3	10	—	
Grey marl	0	3	—	
Black parting	0	1	—	
Strong grey marl [slickenside; small pellets of limestone]	4	1	—	
Brown and grey marl	5	0	—	
Dark-grey marl with boulders [nodules] of Spirorbis limestone [The Index Limestone]	5	8	272	8
Grey sandstone, water 250 gallons per minute	32	10	—	
Strong grey marl	5	3	—	
Brown marl	6	0	—	
Blue bind [grey, slightly micaceous]	0	10	—	
Coal [and mud mixed]	0	3	317	10
Dark grey clunch [slickenside]	5	3	—	
Coal and coaly bind	0	2	—	
Dark-grey marl with pebbles [pellets of sand and limestone]	4	6	—	
Fine grey sandrock	8	6	—	
Coarse sandrock, water 200 gallons per minute	3	6	—	
Grey marl	0	1	—	
Coarse grey sandrock, water 80 gallons per minute	54	5	—	
Light-grey marl	0	3	—	
Dark-grey marl	4	9	—	
Blue bind	8	9	408	0
Brown and grey marl	2	2	—	
Red and grey marl	12	8	—	
Grey marl	9	0	—	
Red and grey marl	25	4	—	
Blue bind	3	6	—	
Coarse grey sandrock with pebbles [up to ½ inch diameter]	23	5	—	
Strong grey marl	0	10	—	

	Thickness. Ft.	In.	Depth Ft.	In.
Fine dark-grey sandstone with pebbles ...	33	6	—	
Light-grey sandstone	5	0	—	
Light rough mixed rock, very hard	4	6	—	
Light-grey sandstone [base of Halesowen Group]	2	6	530	5
Rocky bind, grey and brown	2	2	—	
Purple bind	2	1	—	
Red marl	3	6	—	
Strong blue rocky bind	2	6	—	
Strong rough stone, mixed [coarse greenish sandstone]	6	8	—	
Strong rocky bind, light-grey and purple ...	9	0	—	
Dark-blue bind with balls of stone [concretions]	10	4	—	
Strong rocky bind, grey and purple [typical red and grey marl of Etruria group]	5	4	—	
Grey sandstone	3	8	—	
Red and grey marl, mixed [with chips of shale locally]	86	0	—	
Strong grey bind with balls of stone [plant-remains]	1	6	—	
Red and dark-grey marl	14	6	—	
Black marl [soapy black clay, not carbonaceous]	0	9	—	
Red and grey marl	2	6	—	
Grey rock [Espley type]	4	0	—	
Red and grey marl [base of Etruria Marl Group]	52	5	737	4
Fireclay, dark-grey	1	10	—	
Black batt	1	0	—	
Coal	0	7	740	9
Black batt	0	7	—	
Grey marl	6	5	—	
Red and grey marl	2	0	—	
Black shale	3	3	—	
Coal	0	5	—	
Black batt	0	3	—	
Coal	0	7	754	3
Light grey marl	3	10	—	
Grey rock	1	2	—	
Grey marl	3	2	—	
Red and black marl	3	10	—	
Black shale	3	0	—	
Coal	1	1	—	
Fireclay	0	2	—	
Coal	1	2	773	7
			[771	8]
Fireclay	0	7	—	
Strong stony bind	2	0	—	
Grey bind with ironstone-balls	11	5	—	
Blue bind with bands of stone	6	0	—	
Coal	0	11	795	10
			[792	7]
Strong blue bind	5	1	—	
Rocky bind	6	2	—	
Blue bind	14	2	—	
Coal	2	0	821	8
			[820	0]
Batt and coal	1	5	—	
Fireclay	3	0	—	
Grey sandrock	5	1	—	
Strong bind with bands of stone	8	10	—	
Grey bind	17	5	—	
Dark bind	1	2	—	
Thin Rider Coal. Coal 2 ft., parting 4 ins., Coal 8 ins.	3	0	861	7
			[859	11]
Fireclay	1	1	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Blue bind	21	2	—	
RIDER COAL	5	10	—	
Parting	0	4	—	
BARE COAL. COAL 2 ft. 4 ins., parting 8 ins., COAL 2 ft. 2 ins.	5	2	895	2
			[893	6]
Batt	1	3	—	
Strong sandrock	2	9	—	
Strong rocky bind	11	7	—	
Blue bind	6	10	—	
Black shale	1	0	—	
ELL COAL. COAL 1 ft. 5 in., parting 8 ins., COAL 1 ft.	3	1	921	8
			[920	0]
Fireclay	1	0	—	
Dark-blue bind	7	0	—	
Clunch	0	4	—	
COAL	1	3	931	3
			[929	7]
Strong rocky bind	10	1	—	
SLATE COAL	2	5	943	9
			[942	1]
Fireclay	0	9	—	
Grey clunch with balls of stone	6	6	—	
Strong blue bind	31	0	—	
Grey flint rock	7	8	—	
Grey rocky bind	11	8	—	
Grey flint rock	9	0	—	
Blue bind stone-balls and grey sandstone	27	2	—	
SMITHY COAL. COAL	4	11	—	
Parting	0	0½	—	
COAL	1	5	—	
Parting	0	4	—	
COAL	1	0	—	
Parting	0	9	—	
COAL	2	4	1,039	6
			[1,046	7½]
Bind	7	3	—	
Flint rock	7	0	—	
Blue bind with bands of stone	13	11	—	
Black shale	1	10	—	
Dark bind with layers of ironstone	17	10	—	
THIN COAL	2	0	—	
Parting	1	0	—	
SEVEN-FOOT COAL	6	1	1,096	8
			[1,103	6½]
Strong fireclay	5	2	—	
Strong rocky bind with bands of ironstone, 15 ft. 5 ins. thick, but 5 ft. cut out by a fault	15	5	—	
Black shale	3	6	—	
COAL	0	6	1,120	9
			[1,128	1½]
Black batt	0	4	—	
Fireclay with balls of ironstone	10	4	—	
Strong black shale	0	9	—	
Dark fireclay	2	5	—	
COAL	3	2	1,138	3
			[1,145	1½]
Fireclay	7	9	—	
Blue bind with boulders of ironstone	26	11	—	
COAL	4	5	—	
Parting	0	6	—	
COAL	0	11	—	
Parting	0	6	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
COAL	1	4	—	
Parting	0	3	—	
COAL	4	10	1,186 [1,192	8 6½]
Dark fireclay with balls of stone	9	0	—	
Dark bind	4	0	—	
Strong dark clunch	2	6	—	
Fireclay	1	1	—	
Soft grey bind with balls of ironstone ...	9	0	—	
Dark bind	2	3	—	
Black batt	0	6	—	
COAL	1	9	1,216 [1,222	9 7½]
Fireclay	1	0	—	
Rocky bind with bands of stone	17	5	—	
Blue bind with bands of stone	10	9	—	
COAL	1	3	1,244 [1,253	11 0½]
Black batt	0	2	—	
Soft clunch and fireclay	7	6	—	
Light sandrock	2	8	—	
Rocky bind	15	6	—	
Blue bind with balls of ironstone	44	6	—	
Dark bind	11	0	—	
Espley Rock	3	0	—	
Red and dark-grey marl mixed	4	7	—	
Dark-blue bind	4	7	—	
Dark fireclay	1	7	—	
Black shale and fireclay mixed	1	10	—	
Red and dark marl mixed	8	5	—	
Strong rocky bind	2	6	—	
Dark bind with balls of stone	7	4	—	
Red and grey marl mixed	7	8	—	
Dark fireclay	8	1	—	
COAL and batt	0	3	1,372 [1,384	4 2½]
Dark bind	3	8	—	
Conglomerate	1	7	—	
Light rock	1	0	—	
Red and grey marl mixed	11	5	—	
Dark-grey rocky bind	3	0	—	
Conglomerate	2	0	—	
Red and grey marl	2	6	1,397 [1,409	6 4½]

Heckley Hall, No. 4 *Shaft.*—Six-inch Map, Warwick. 5 N.E.
Lat. 52° 35′ 40″. Long. 1° 40′ 35″ W.
Communicated by the Kingsbury Colliery Company.
Height above O.D., about 250 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Soil	0	6	0	6
Clay	7	0	—	
Penny stone	1	10	—	
White clod	2	5	—	
COAL	0	2	11	11
Bastard fireclay	5	6	—	
Marl	2	6	—	
Rock	3	11	—	
Fireclay	3	10	—	
Black bat	0	7	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Fireclay	8	4	—	
Black slums	0	10	—	
Fireclay	4	2	—	
COAL	0	9	42	4
Fireclay	2	3	—	
Rock	2	1	—	
Strong rock	5	0	—	
Stone measures	4	0	—	
Pricking	0	4	—	
Bind clod	9	8	—	
Stone measures	3	0	—	
White bind clod	3	9	—	
Dark bind clod	3	8	—	
COAL	1	7	79	8
Slums	2	11	—	
Fireclay	5	0	—	
Rock binds	8	6	—	
Bind clod	22	0	—	
Strong blue clod	0	8	—	
COAL. BROOCH COAL (very good)	3	0	—	
Pricking	0	4	122	1
Fireclay	3	0	—	
Bastard fireclay	6	8	—	
Sandstone rock	10	4	—	
White clod	3	6	—	
Blue clod	0	6	—	
COAL, the RIDER, now worked	4	0	—	
Pricking 4 in. Inferior Coal 9 in.	1	1	151	2
Fireclay	4	0	—	
Rock binds	3	0	—	
Ironstone	0	9	—	
Strong bind clay	15	3	—	
Coal and stone, mixed	2	0	—	
COAL	2	0	178	2
Fireclay, stony	2	8	—	
Strong fireclay rock	2	10	—	
Strong grit rock	7	0	—	
Rock binds	7	9	—	
COAL	1	9	200	2
Fireclay	5	6	—	
Slums	0	9	—	
COAL	0	7	—	
Fireclay parting	0	7	—	
Fireclay rock	3	10	—	
Rock binds	4	9	—	
Dark strong rock	2	2	—	
Strong bind clod	8	9	—	
COAL	1	7	228	7
Fireclay rock	7	9	—	
Bind clod	4	2	—	
Strong black rock	3	6	—	
Parting	0	3	—	
COAL	2	6	246	9
Fireclay	1	0	—	
Fireclay rock	6	1	—	
Dark strong rock	5	9	—	
Strong rock binds	7	0	—	
Dark clod	1	0	—	
Strong rock mixed with ironstone	7	7	—	
COAL	2	3	277	5
Strong grizzly rock	5	10	—	
Peldon	0	9	—	
Rock binds	1	10	—	
Bind clod	6	10	—	

		Thickness. Ft.	In.	Depth. Ft.	In.
Top of Smithy stone		0	8	—	
[1]White clod, cakes of ironstone		3	7	—	
[1]Bottom ironstone (good)		0	3	—	
Dark clod		1	9	—	
Pricking		0	2	—	
[1]Coal (good)—Smithy Coal		1	8	300	3
Slums		0	10	—	
Fireclay rock		7	5	—	
Rock binds		11	7	—	
Bed of ironstone		0	2	—	
Strong rock binds		6	0	—	
Bed of ironstone		0	2	—	
Strong clod		2	3	—	
Top White Ironstone ...	Worked for some years.	0	3	—	
Strong clod		3	7	—	
Bottom Ironstone ...		0	5	332	11
Dark grey clod		16	4	—	
Strong bind clod...		4	0	—	
Top Coal ...	Seven-foot Coal	2	9	—	
Scarps ...		0	6	—	
Main Coal[2]		5	6	362	0
Parting (? 3 in., thickness not stated)					
Coal, inferior ...		2	9	—	
Parting		0	1	—	
Coal inferior ...		1	9	—	
Parting, (batt) ...		0	1	—	
Coal, inferior ...		1	8	—	
Parting		0	5	368	9
Rock binds		12	3	—	
Sandstone rock		6	0	—	
Sharp strong rock		3	6	—	
Fireclay rock		5	0	—	
Strong bleeding rock		12	0	—	
Bastard fireclay		7	6	—	
Ball ironstone measures		3	6	—	
Coal, good	Double Coal ...	3	0	—	
Dark slums		3	6	—	
Coal and batt		1	0	—	
Dark fireclay		3	0	—	
Slums		1	9	—	
Coal		1	0	—	
Parting		0	3	—	
Coal		2	4	—	
Batt and fireclay ...		3	0	—	
Coal, good, but tender ...		3	9	447	10
Fireclay, good		4	9	—	
Strong rock		4	6	—	
Entered good strong rock		1	6	458	7

The depths to the different seams were carefully measured; they differ slightly from the totals obtained by adding the details.

Hockley Hall, Boring from Base of No. 1 *Shaft* (Plate at end of Volume).

About 200 yards N.W. of No. 4, given above.

	Thickness. Ft.	In.	Depth. Ft.	In.
Seven-feet Coal	—		—	
Sump	19	0	19	0
Strong rock binds	19	6	—	

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[1] Ironstone and coal formerly worked together.

[2] Bed of pyrites 2 ft. from bottom.

		Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Sandstone rock		7	0	—	
Bastard fireclay rock		12	1	—	
Ball ironstone, uneven		1	0	—	
Coal, good, but tender ...	Double Coal ...	3	0	61	7
Fireclay		3	0	—	
Black slums		4	6	—	
Coal		3	0	72	1
Fireclay		0	9	—	
Slums		0	3	—	
Fireclay		2	9	—	
Coal		3	6	79	4
Fireclay, ironstone balls...		4	8	—	
Strong blue binds		18	0	—	
Rock binds		17	0	—	
Coal		0	6	119	6
Dark fireclay and batts		6	6	—	
Coal, Bench Coal (good but dull)		6	0	132	0
Fireclay		9	3	—	
Ironstone, very good		0	6	—	
Dark fireclay and stone balls		5	0	—	
Coal		0	10	147	7
Fireclay and ironstone balls		12	5	—	
Ironstone, good, 4 ins., pricking 4 ins., ironstone 1½ ins., binds, 2½ ins., ironstone 4 ins.		1	4	161	4
Black binds		3	6	—	
Coal, very bright		1	5	166	3
Fireclay		4	0	—	
Strong binds		3	0	—	
Ironstone		0	2	173	5

The No. 1 Shaft was used to mine the Smithy Coal and Ironstone as well as the underlying Seven-Foot Coal. From the bore of the latter this boring was put down to prove the ironstones below the Bench Coal; no workings were made in these.

Kettlebrook Collieries, Dumolo's Pit (Plate at end of Volume).—Six-inch Warwick. 2 S.E.

Lat. 52° 37′ 5″. Long. 1° 39′ 46″ W.

Published in Sheet 21 of the Vertical Sections of the Geological Survey.

Height above O.D., about 250 ft.

	Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Raised ground	5	0	5	0
Brown soil	0	10	5	10
Yellow clay	2	0	—	
Red clay	1	0	8	10
Blue clay	7	0	—	
Brown sand and blue bind	10	9	—	
Grey stone and blue bind	13	9	—	
Grey stone	12	8	—	
Blue bind with red mixed [Base of Etruria Marls]	11	0	64	0
Red and grey clunch	7	8	—	
Black bind with coal	0	6	72	2
Stone bind	9	6	—	
Blue bind	27	0	—	
Brown stone	1	0	—	
Blue bind	21	0	—	
Brown stone	1	0	—	

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Blue bind	26	0	—	
Black batt	0	5	—	
COAL	1	6	159	7
Clunch	6	0	—	
Blue bind	33	0	—	
Stone bind	10	0	—	
Blue bind	17	0	—	
COAL	1	0	226	7
Clunch	8	0	—	
Blue bind	24	0	—	
Whitestone	7	0	—	
COAL	1	6	267	1
Strong clunch	9	0	—	
White sandstone	2	6	—	
Strong rocky bind	4	0	—	
White sandstone, sherry	15	0	—	
Blue bind	1	6	—	
COAL	2	3	301	4
Fireclay; ironstone balls	6	0	—	
Blue bind	10	6	—	
Batt	0	6	—	
Rocky bind	7	6	—	
Hard blue stone	2	3	—	
Blue bind	10	6	—	
COAL	1	4	339	11
Rocky clunch	6	6	—	
Rocky bind, ironstone	9	6	—	
Bat, clunch and coal mixed. Slate	7	3	—	
Rocky clunch, ironstone balls	6	6	—	
Mild bind, ironstone balls	4	6	—	
COAL	0	3	374	5
Rocky bind	10	3	—	
Bind	1	6	—	
COAL, clear dice	1	10	388	0
Dun fireclay	2	3	—	
Rocky clunch, ironstone balls	6	6	—	
Blue bind, ironstone balls	8	6	—	
Brown ironstone	0	4	—	
Dark bind	1	6	—	
Brown ironstone	0	6	—	
Soft clunch	1	6	—	
Light bind	0	6	—	
COAL (bright) SMITHY COAL	2	4	411	11
Clunch and batt	4	6	—	
White sandstone	3	6	—	
Strong red bind	1	3	—	
White sandstone	1	6	—	
Blue bind, ironstone beds	15	6	—	
Ragg	0	6	—	
Soft blue bind	4	9	—	
COAL, with a hard black stone	1	3	444	8
Light clunch	5	0	—	
Dark clunch	5	6	—	
COAL. SEVEN-FOOT COAL	7	6	462	8
Fireclay and clunch	1	6	—	
Strong rocky clunch	4	0	—	
Hard stone	0	8	—	
Strong rocky clunch	2	10	471	8

The workings from this shaft in the Seven-Feet Coal were stopped by a large fault, and the mine was abandoned. Later on a second shaft was sunk by a new company, starting at a lower horizon below the Etruria Marls; it was carried down to the Double Coal. As the two shafts are only 300 yards apart the details are much the same, and the section of the second is given in abstract as follows:—

Kettlebrook Collieries, Cagg's Pit.—Six-inch Map, Warwick. 2 S.E.

Lat. 52° 37′ 12″. Long. 1° 39′ 55″ W.

Height above O.D., about 250 ft.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Measures	240	0	240	0
SMITHY COAL	2	4	242	4
Measures	42	8	285	0
SEVEN FEET COAL	7	6	292	6
Measures	127	6	420	0
DOUBLE COAL; COAL 3 ft., parting 2 ft., COAL 3 ft.	8	0	428	0

The section of the Double Coal varies considerably, chiefly through the diminution in thickness of the parting; the lower coal is sometimes as much as 5 ft. thick.

Kingsbury Colliery Shaft (Plate at end of Volume).—Six-inch Map, Warwick. 5 S.E.

Lat. 52° 34′ 50″. Long. 1° 39′ 39″ W.

Communicated by the Company.

Height above O.D., 310 ft.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Soil and clay	2	0	—	
Yellow marl	16	6	—	
Blue shale clay	11	3	—	
Brown rock mixed with ditto [The Brown Sandstone]	19	3	—	
Grey rock with black streaks and fossils	25	3	—	
Grey rock with black streaks	6	9	—	
Drift with shale pebbles	1	0	—	
Grey sandstone rock, passing to harder rock	24	3	—	
Drift	0	6	—	
Limestone [see note at end]	9	0	115	9
Drift	0	9	—	
Grey sandstone rock	15	0	—	
Conglomerate, mixed with grey rock and ironstone nodules	18	0	—	
Fireclay	1	6	—	
Strong stony binds	4	0	—	
Softer binds	10	0	—	
Grey rock [Base of Halesowen Group]	74	6	239	6
Marl, largely reddish	159	6	399	0
Grey bind	1	8	—	
Red marl	10	7	—	
Clunch	0	3	—	
Red marl mixed with stone	39	0	—	
Sandstone rock	5	8	—	
Red marl	6	1	—	
Stony bind	0	7	—	
Soft bind	0	11	—	
Marl [red in part] mixed with clunch [Base of Etruria Marl]	15	1	478	10

	Thickness. Ft.	In.	Depth. Ft.	In.
Black clunch	2	4	—	
Grey bind	2	10	—	
Black clunch	3	5	—	
Coal	1	3	488	8
Grey clunch, mixed with fireclay	4	6	—	
Black clunch	0	4	—	
Grey bind	3	1	—	
Blue and grey bind and clunch	4	10	—	
Sandstone rock	13	11	—	
Grey bind	1	4	—	
Yellow stone	7	6	—	
Black clunch	1	2	—	
Black shale	1	0	—	
Black clunch	3	4	—	
Dark grey sandstone	2	8	—	
Dark grey bind	12	10	—	
Ironstone	0	6	—	
Strong stone	6	0	—	
Strong sandstone	2	4	—	
Blue bind	4	0	—	
Light grey sandstone	5	6	—	
Brown ironstone	0	8	—	
Blue bind	16	6	—	
Black shale	0	6	—	
Coal	2	0	583	2
Grey clunch and ironstone balls	6	10	—	
Strong dark blue bind	9	0	—	
Light grey rock	3	9	—	
Coal (one side of pit)	1	5	604	2
[Pricking]	0	2	—	
Coal (one side of pit)	2	1	606	5
Dark brown clunch with ironstone balls	3	0	—	
Strong dark blue bind with ironstone balls	14	7	—	
Coal } called Upper Rider	4	0	—	
Pricking dirt } called Upper Rider	0	2	—	
Coal } called Upper Rider	2	10	631	0
Dark blue clunch	3	6	—	
Strong sandstone with black streaks	2	6	—	
Hard grey rock	0	6	—	
Coal and shale }	3	0	—	
Black stone with ironstone }	0	8	—	
Coal }	2	6	643	8
Shale and clunch	3	6	—	
Coal } Rider Coal [seam worked]	3	6	—	
Parting } Rider Coal [seam worked]	0	3	—	
Coal } Rider Coal [seam worked]	2	4	653	3
Dark grey rock	0	5	—	
Soft clunch and shale	1	5	—	
Coal	0	9	655	10
Shale and dirt	1	4	—	
Soft bind, coal and shale	1	5		
Hard sandstone	13	8	—	
Blue bind	5	7	—	
Black shale and bind	1	4	—	
Coal	1	10	—	
Light soft pricking	0	5	—	
Coal	0	11	682	4
Soft pricking dirt	0	5	—	
Strong clunch	9	3	—	
Dirt	0	3	—	
Coal	1	5	693	8
Stony clunch	5	4	—	
Coal, rock and clunch	1	0	—	
Coal	1	3	701	3

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Clunch	5	3	—	
Bind	9	0	—	
Stony bind	3	6	—	
COAL and batt	0	9	—	
Clunch	1	11	—	
Blue bind	10	0	—	
Stony bind	5	6	—	
Rock	2	10	—	
Stony bind	2	0	—	
Rock	6	6	—	
Stony bind	1	10	—	
Sandstone rock	12	2	—	
COAL	2	4	764	10
Soft pricking	0	9	—	
Strong clunch	3	9	—	
Sandstone rock	9	0	—	
Blue bind	1	0	—	
Rocky bind	7	0	—	
Black clunch	1	2	—	
Blue binds	20	2	—	
Dark binds with ironstone balls	14	11	—	
Dark blue binds	4	0	—	
COAL, SEVEN-FEET COAL	7	10	834	5
Pricking and batt	1	1	—	
Coal	0	11	836	5
Black batt	2	2	—	
COAL	3	9	842	4
Grey clunch	2	5	—	
Black clunch	1	4	—	
Black batt	1	1	—	
Strong grey clunch	5	4	—	
Rock binds	2	6	—	
Strong rock	2	0	—	
Stony binds	1	0	—	
COAL	2	10	860	10
Fireclay	4	3	—	
COAL and pricking	1	3	—	
Fireclay	2	6	—	
COAL	1	9	870	7
Fireclay	4	4	—	
COAL	3	4	878	3
Clunch	3	0	—	
Stony clunch	4	0	—	
Bind	2	10	—	
COAL	0	10	888	11
Stony clunch	12	2	—	
Stony bind	9	3	910	4

An account of this sinking (down to 682 ft.) and the methods of coping with the great volume of water encountered, is given in a paper by J. P. Kendrick 'On Sinking Operations at Kingsbury Colliery, Warwickshire,' *Trans. Fed. Inst. Mining Engineers*, vol. xiii, 1896-97, pp. 269-276. It is there stated that the 'calcareous conglomerate' met with in the water-bearing sandstones occurred as boulders [of limestone] in the sandstone. The water occurred in the Halesowen Sandstone; the first feeder, averaging 60,000 gallons an hour, was met with in the upper sandstones at a depth of about 135 ft.; this is part of the thick brown sandstone described on p. 45; a second and similar feeder was met with at 192 ft. in the basal sandstone of this group. The underlying mass of Etruria Marl shut out any further serious inflow. See also p. 217.

Tame Valley Shaft (Plate at end of Volume).—Six-inch Map, Warwick. 5 N.E.

Lat. 52° 36′ 7″. Long. 1° 40′ 20″ W.

Communicated by Mr. J. Cooke for Messrs. Skey & Co.

Height above O.D., about 230 ft.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Raised ground	18	0	18	0
Red marl	33	0	—	
Coal, dirt parting	1	0	52	0
Blue binds	5	0	—	
Fireclay, with ironstone nodules	9	0	—	
Blue fireclay	7	0	—	
Coal, about 9 ins.	0	9	73	9
Fireclay	11	3	—	
Red marl [Base of Etruria marls]	8	0	93	0
Fireclay	6	0	—	
Coal	0	9	99	9
Blue rock	5	3	—	
Blue binds with ironstone nodules	13	6	—	
Coal	0	9	119	3
White rock	6	9	—	
Rock binds	9	3	—	
Blue binds	9	0	—	
Batt and Coal	3	0	147	0
Dark shale	6	0	—	
Dark fireclay	9	0	—	
Blue binds	6	0	—	
Rock binds	4	6	—	
Blue binds, with a band of ironstone	13	6	—	
Batt 1½ ft. on Yard Coal	4	6	190	6
Fireclay and ironstone	9	0	—	
Dark rock	6	0	—	
Blue binds	4	6	—	
Rider or Four-foot Coal	7	6	217	6
Good fireclay; ironstone at base	7	6	—	
Dark rock-binds	7	6	—	
Blue binds	7	6	—	
Batty Coal	3	0	243	0
Fireclay rock	7	6	250	6
White sandstone with coal-streaks	4	6	—	
Blue bind	3	0	—	
White sandstone with coal-streaks	3	0	—	
Blue binds	3	0	—	
Coal	0	9	264	9
Fireclay	8	3	—	
Blue binds	6	11	—	
Coal and fireclay	0	1	280	0
Blue binds, one sand film	12	6	—	
Coal	1	6	294	0
Fireclay, sandy base	9	0	—	
Blue binds	6	0	—	
Batt	10	6	—	
Fireclay	4	6	—	
Blue binds, 2 feet of sandstone in middle	25	6	—	
Coal	3	0	352	6
Fireclay	7	6	—	
Dark sandstone	4	0	—	
Blue binds, 2 bands of ironstone	11	0	—	
Smithy Coal	3	0	378	0
Batt	3	0	—	
Main stone	10	6	—	
Blue binds, 2 small bands of fireclay at top	27	0	—	

	Ft.	In.	Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
SEVEN-FEET COAL (includes the THIN COAL) ...			9	0	427	6
Fireclay	0	6	7	6	—	
COAL	0	9				
Dark fireclay ...	1	3				
COAL and batt ...	1	3				
Batt	1	6				
COAL	2	3				
Fireclay			9	0	—	
Binds and ironstone			15	0	459	0

A heading was driven level to the west where the beds rise sharply, and the Double Coal was cut at a depth of 66 ft. below the Seven-Feet.

Whateley Colliery Shaft (Plate at end of Volume).—Six-inch Map, Warwick. 5 N.E.

Lat. 52° 35′ 25″. Long. 1° 40′ 25″ W.

Communicated by the Kingsbury Colliery Company.

Height above O.D., 255 ft.

	Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Soil	1	3	—	
Clay	3	6	—	
Marl	3	3	—	
Light marl	2	0	—	
Red marl	84	0	94	0
Rock	0	4	—	
Binds	1	0	—	
Fireclay	3	0	—	
Red marl	4	0	—	
Dark fireclay	3	0	—	
Red marl	2	6	—	
Dark fireclay	3	0	—	
Black batt	0	3	111	1
Fireclay	9	11	—	
Red marl	6	0	—	
Dark fireclay	5	6	—	
Sandstone rock	2	6	—	
Red marl	12	3	—	
Very hard fireclay	0	6	—	
Red marl [base of Etruria Marl]	6	6	154	3
Fireclay	2	0	—	
COAL	0	4	156	7
Very dark fireclay	0	7	—	
Bat	0	6	—	
Dark fireclay (extra good)	6	0	—	
Strong light fireclay	2	6	—	
Dark fireclay, mixed with ironstone	6	0	—	
Dark fireclay	2	0	—	
Black ring	0	6	—	
Light fireclay	3	0	—	
COAL	0	8	—	
Black bat	0	4	178	8
Black rock	3	6	—	
Strong grey sandstone rock	15	6	—	
Blue bind	1	0	—	
Ironstone	0	1	—	
Blue bind	4	0	—	
Ironstone	0	3½	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Blue bind	2	4	—	
Ironstone	0	3½	—	
Blue bind	1	7	—	
Ironstone	0	4¼	—	
Blue bind	2	0	—	
Ironstone	0	3¼	—	
Blue bind	3	3	—	
Pricking	0	1	—	
Dark bind	2	2	—	
Black batt	0	6	—	
COAL. (HALF-YARD COAL)	1	7	217	6
Slums	3	6	—	
Fireclay	5	6	—	
Blue bind	3	0	—	
Ironstone	0	2	—	
Blue bind	12	9¼	—	
Dark rock (sandstone)	3	0	—	
Rocky binds	3	6	—	
Blue binds	14	10	—	
Black binds and soft black slums	0	10	—	
COAL. YARD COAL	2	10	267	5¼
Dark fireclay	3	4	—	
Clunch	6	0	—	
White ironstone rock	0	8	—	
Blue bind	7	4	—	
Black batt and soft slums	0	4	—	
COAL } RIDER, OR FOUR-FEET COAL	3	2	—	
Pricking	0	2½	—	
COAL	0	9	—	
Black batt	0	2	289	4¾
Fireclay	6	0	—	
Stone bind	7	6	—	
Bind shale	1	6	—	
COAL, stony	3	0	—	
COAL	1	0	308	4¾
Strong rock	3	0	—	
Rock Bind	20	6	—	
COAL	1	3	—	
Fireclay	0	5	—	
COAL	1	0	334	6¾
Clunch	3	0	—	
Rock-binds, balls of ironstone	12	0	—	
COAL	1	2	350	8¾
Strong binds	14	0	—	
Black ring stone	3	4	—	
COAL, hard	1	2	369	2¾
Fireclay	1	0	—	
Strong clunch	5	6	—	
Strong bind, balls of ironstone	17	6	—	
Shale with streaks of coal	2	6	—	
Blue binds	3	0	—	
Dark hard rock	5	6	—	
Rocky binds, balls of ironstone	12	0	—	
COAL (bright dicey seam)	2	3	418	5¾
Light clunch	1	0	—	
Dark clunch	1	2	—	
Grey rock	4	3	—	
Strong clunch	7	0	—	
Stone 2 in., fireclay 6 in., stone 2 in., fireclay 8 in., stone 2 in.	1	8	—	
Dark bind, balls of ironstone	5	0	—	
Pricking	0	2	—	
COAL, SMITHY COAL	2	6	441	2¾
Rock clunch	11	6	—	

		Thickness. Ft.	In.	Depth. Ft.	In.
Mixed sand-rock		2	6	—	
Strong bind		5	6	—	
Peldon		0	8	—	
Blue binds, iron bands 2 in. thick		8	4	—	
Top white ironstone 2½ in., soft blue bind 3 ft., Bottom Ironstone 3 in.		3	5½	—	
Blue binds with beds of stone		20	5	—	
COAL, the Thin COAL	SEVEN-FEET COAL	2	3	—	
Batt		0	1	—	
Scorps		0	6	—	
COAL		5	9	502	2
Pricking 2 in., coal 2 in., batt 3 in.		0	7	—	
Inferior COAL		0	8	—	
Batt and fireclay		1	7	—	
BATT COAL		4	5	509	5
Batt and fireclay		4	6	—	
Strong binds with balls of stone		16	9	—	
Stone band		0	6	—	
Strong rock clunch		8	0	—	
Strong bind, balls of stone		8	0	547	2

Wilnecote Colliery (Plate at end of Volume).—Messrs. Perrin & Harrison.—Six-inch Map, Warwick. 5 N.E.

Lat. 52° 36′ 40″. Long. 1° 39′ 52″ W.

Height above O.D., about 300 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Soil and yellow clay	3	0	—	
Purple and red marl	13	0	—	
SOFT COAL	0	3	16	3
Purple Marl	26	0	—	
Fine conglomerate	3	0	—	
Purple marl	21	0	—	
White sandstone	10	6	—	
Purple marl	9	0	—	
Soft COAL	0	3	86	0
Purple marl	15	6	—	
White sandstone	9	0	—	
COAL and batt	1	0	111	6
Fireclay	6	0	—	
Marl	7	0	—	
Fine conglomerate	3	0	—	
Marl	6	0	—	
Red marl [Base of Etruria Marls]	6	0	139	6
COAL and batt	1	6	141	0
Blue binds	10	0	—	
COAL and batt	0	6	151	6
Dark fireclay	1	0	—	
Binds	8	6	—	
COAL	0	9	161	9
Fireclay	0	6	—	
White sandstone with fine streaks of coal intermixed. Open fissures	41	0	—	
COAL	1	0	204	3
Fireclay	1	0	—	
Bind with small nodules of ironstone	4	0	—	
Sandstone streaked with coal	0	9	—	
Strong rock (peldon) with fissures	2	0	—	
Sandstone streaked with coal	1	0	—	
Binds	0	6	—	
Strong rock (peldon) with fissures	1	3	—	

	Thickness.		Depth	
	Ft.	In.	Ft.	In.
Binds	23	0	—	
COAL and batt	1	6	239	3
Fireclay	4	9	—	
Soft shale and fireclay	8	6	—	
Fireclay	10	6	—	
Mottled ground	6	0	—	
Soft shale (black)	4	0	—	
Binds	4	0	—	
Sandstone	3	6	—	
Binds	17	6	—	
Batt	0	9	—	
Fireclay	0	3	—	
COAL (supposed to be the RIDER COAL)	3	8	302	8
Fireclay	0	6	—	
Fireclay rock	7	0	—	
Soft shale (black)	0	6	—	
Binds	1	6	—	
Batt with ironstone-nodules	8	6	—	
Fireclay	1	0	—	
Fireclay rock	11	0	—	
Binds	19	6	—	
Batt	0	3	—	
Fireclay	3	0	—	
Batt	0	6	—	
COAL	1	8	357	7
Soft batt	0	6	—	
Fireclay	1	6	—	
Fireclay rock	8	0	—	
White sandstone (skerry rock)	17	0	—	
Binds	1	9	—	
Batt (fresh-water mussels)	0	6	—	
BRIGHT COAL	1	5	388	3
Dark fireclay	2	0	—	
Fireclay rock	8	6	—	
White sandstone rock streaked with coal	8	3	—	
Binds	2	0	—	
Soft shale and COAL	1	4	—	
White sandstone streaked with Coal	6	0	—	
Strong binds	7	3	—	
Blue binds with ironstone	6	0	—	
COAL	1	6	431	1
Fireclay	1	3	—	
Rock	6	0	—	
Strong binds	4	0	—	
Binds	3	6	—	
Batt	3	0	—	
Fireclay	0	6	—	
Batty Coal [Slaty refuse Coal]	3	7	452	11
Fireclay rock	7	6	—	
Sandstone streaked with Coal	8	0	—	
White sandstone	8	3	—	
Binds	2	0	—	
COAL	2	0	480	8
Fireclay with nodules of ironstone	6	0	—	
Sandstone	4	0	—	
Binds	4	9	—	
Binds with ironstone	4	0	—	
Batt	1	9	—	
COAL, bright hard. SMITHY COAL	1	9	502	11
Fireclay	2	6	—	
Fireclay with ironstone-nodules	1	0	—	
Hard sandstone "main stone."	3	6	—	
Sandstone streaked with coal	1	0	—	
Hard sandstone	3	0	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Blue binds	13	0	—	
Ferruginous sandstone, "ragg"	1	0	—	
Dark binds	7	0	—	
COAL	1	6	536	5
Binds	17	0	—	
"SEVEN FEET" or "MAIN COAL." [Sound, good quality.]	7	9	561	2

On the plan deposited in the office of the Geological Survey the true depth of five of the coals is given as follows:—

To Rider Coal	308 feet.
,, Bright Coal	393⅔ ,,
,, Batty Coal	459½ ,,
,, Smithy Coal	510 ,,
,, Seven Feet Coal	570 ,,

Water was met with at 111 ft.; at 203 ft. (700 gallons a minute); at 213 ft., and at 302 ft.

The coal supposed to be the Rider, at 300 ft., is soft but clean; hot burning, with no sulphur.

Wilnecote Brick and Tile Works, No. 1. *Peel Shaft* (Plate at end of Volume), Messrs. Skey & Co.—One-inch Map (N.S.), 154. Six-inch Warwick. 5 N.E.

Lat. 52° 36′ 40″. Long. 1° 40′ 35″ W.

Communicated by Mr. John Cooke for Messrs. Skey & Co.

Height above O.D., about 250 ft.

	Thickness. Ft.	In.	Depth. Ft.	In.
Measures	10	0	10	0
COAL	1	6	11	6
Measures	35	6	47	0
COAL	1	0	48	0
Measures	19	0	67	0
COAL	3	0	70	0
Measures	32	6	102	6
COAL	1	6	104	0
Measures	18	0	122	0
SMITHY COAL	2	0	124	0
Measures	29	0	153	0
THIN COAL	1	0	154	0
Measures	11	0	165	0
SEVEN-FEET COAL	7	0	172	0
Measures	27	0	199	0
SPAR COAL	1	0	200	0
Measures	38	0	238	0
COAL	3	0	241	0
Measures	17	6	258	6
COAL	0	6	259	0
Bind	2	0	261	0
COAL Parting COAL } DOUBLE COAL	8	0	269	0
White clay (mined)	5	0	274	0
Measures	46	0	320	0
BENCH COAL	4	0	324	0
Measures	39	6	363	6
COAL	1	6	365	0
Measures	30	0	395	0

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
COAL	1	0	396	0
Yellow clay (mined)	3	0	399	0
Measures	11	0	410	0
White sandstone	26	0	436	0
Peldon	14	0	450	0
White rock, passing to rocky binds	15	0	465	0
Blue binds	25	0	490	0
Strong black clunch	12	0	502	0
Red and white marl	10	0	512	0
Hard black shale with ironstone nodules	40	0	552	0
Red and yellow clay	16	0	568	0
Measures	13	0	581	0
Rough conglomerate rock	9	0	590	0
Measures	4	0	594	0
White rock, with fossil stems	8	0	602	0
Black bass (shale) with ironstone nodules	26	0	628	0
Rocky fireclay	2	0	630	0
Hard siliceous rock	18	0	648	0
Hard black ground	4	0	652	0
Red rocky marl	24	0	676	0
Rough conglomerate rock[1]	6	0	682	0
Red marly rock	28	0	710	0
Rough rock with black (coal) smut	1	0	711	0
In white rock	3	0	714	0

Shaft to 400 ft., boring below. For observations on this and the other shafts in this royalty see pp. 29, 31, 32.

Wilnecote Brick and Tile Works, No. 3 *or Corner Pit.*—Six-inch Map, Warwick. 5 N.E.

Lat. 52° 36′ 47″. Long. 1° 40′ 18″ W.

Communicated by Mr. J. Cooke for Messrs. Skey & Co.

Height above O.D., about 250 ft.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Commencing a little below the Rider Coal	—		—	
Measures	6	0	6	0
COAL	1	0	7	0
Measures	35	0	—	
Ironstone [band or nodules]	0	6	—	
Blue clod	4	6	—	
COAL	1	0	48	0
Rock and Clod	18	0	—	
Ironstone	0	6	—	
Black ground	2	6	—	
COAL	3	0	72	0
Fireclay	3	0	—	
Blue clod with ironstone	6	0	—	
Rock	20	0	—	
COAL	2	6	103	6
Fireclay, Ironstone at base	7	6	—	
Strong clod	10	0	—	
Dark clod with two beds of ironstone[2]	3	0	124	0
SMITHY COAL[2]	2	0	126	0
Fireclay	3	0	—	

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[1] This and beds below probably belong to the Millstone Grit; possibly the upper 'rough conglomerate rock' may do so, but the black-bass with ironstone nodules seems to belong rather to the beds of Coal Measure age, but below the workable coals, see pp. 24, 29.

[2] Worked either from this or some other of the numerous pits in the royalty.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Main stone	7	0	—	
Clod and bind with ironstone	17	0	—	
Clod	3	0	—	
THIN COAL	2	6	158	6
Strong clod	4	6	—	
SEVEN FEET COAL	7	0	170	0
Fireclay	4	0	—	
Brown fireclay	5	0	—	
Dark fireclay	2	6	—	
Light clay	4	6	—	
Measures (ironstone nodules worked in No. 7 Pit)[1]	12	0	—	
SPAR COAL	2	6	200	6
Measures	9	6	—	
Brown Ironstone measures[1]	7	0	217	0
Measures	22	0	—	
COAL	3	6	242	6
Measures	16	6	—	
COAL 3 ft. Fireclay 1 ft. COAL[1] 5 ft. } DOUBLE COAL[1] (variable thickness).	9	0	268	0
White plastic fireclay (extensively mined)	5	0	273	0
Measures	47	0	—	
BENCH COAL[1]	5	0	325	0
Measures	12	0	—	
Black Ironstone in binds[1]	2	0	339	0
COAL	2	0	341	0
Measures	24	0	—	
COAL	1	6	366	6
Measures	31	6	—	
COAL	1	0	399	0
Dark shale	1	0	—	
Fireclay (lowest worked), varies	3	0	403	0
In stony rock, to	5	0	408	0

2. SHAFTS AND BORINGS FOR WATER.

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

No. 1, *Brindley Bank.*—Shaft and boring close to the Stafford Road, a mile N.W. of Rugeley. One-inch Map (N.S.), 140. Six-inch Staffs. 45 N.E.

Lat. 52° 46′ 20″. Long. 1° 56′ 38″ W.

Made by Messrs. Timmins & Sons, 1903, and communicated by Mr. H. Ashton Hill. Shaft 36 ft.; remainder bored. Average daily yield in 1915 was 628,948 gallons.[2]

Top 247 ft. above Ordnance Datum.

	Thickness.		Depth.	
Superficial :—	Ft.	In.	Ft.	In.
Soil	0	6	0	6
Fine gravel	2	9	3	3
Lower Keuper Sandstone :—				
Grey sandstone	9	9	—	
Clay	2	2	—	
Grey sandstone	0	9	—	
Red marl	0	1	—	
Red loamy sandstone	1	2	—	

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[1] Worked either from this or some other of the numerous pits in the royalty.

[2] 'Return as to Water Undertakings in England and Wales, *Local Gov. Board*,' 1915, p. 216.

	Thickness. Ft.	In.	Depth. Ft.	In.
Lower Keuper Sandstone :—cont.				
Grey sandstone	1	3	—	
Red clay	3	11	—	
Grey sandstone	5	9	—	
Soft red sandstone	0	3	—	
Red and yellow clay	0	9	—	
Soft red loamy sandstone	1	3	—	
Soft red clay	0	6	30	10
Bunter Pebble-Beds :—				
Red sandstone	32	2	—	
Coarse red sandstone and small pebbles	31	0	—	
Red sandstone	2	0	—	
Coarse red sandstone and small pebbles	48	0	—	
Red sandstone	16	0	—	
Hard sandstone and pebbles	3	0	163	0
Plastic marl	1	6	—	
Sandstone and large pebbles	23	6	—	
Conglomerate	26	0	—	
Light red sandstone and pebbles	12	6	—	
Thin layer of marl	0	6	227	0
Light red sandstone and gravel	50	0	—	
Hard fine-grained sandstone	12	0	—	
Light red sandstone and gravel	26	0	—	
Conglomerate	99	0	414	0
Grey sandstone	53	0	—	
Hard red sandstone	7	0	—	
Grey sandstone	4	0	478	0
Marl	17	0	—	
Fine-grained light sandstone	2	0	497	0
Coal Measures or *Millstone Grit* :—				
Red and blue marl	10	0	507	0

Seven Springs.—Shaft and Boring near Shooting Butts Farm, one and a half miles west of Rugeley. One-inch Map (N.S.), 140. Six-inch Staffs. 45 S.E.

Lat. 52° 45′ 26″. Long. 1° 58′ 42″ W.

Made 1901-1902; communicated by Mr. H. Ashton Hill.

Wholly in Bunter. Not used.

Top 400 ft. above Ordnance Datum.

	Thickness. Ft.	In.	Depth. Ft.	In.
Running gravel	15	2	15	2
Red sandstone (dipping at 5°)	3	8	—	
Gravel with large stones	7	2	—	
Red sandstone	8	2	—	
Conglomerate (dipping at 10°)	16	7	—	
Grey sandstone	16	8	—	
Conglomerate	5	1	—	
Gravel	2	0	—	
Gravel with large stones	34	6	—	
Gravel (dipping at 15°)	10	6	—	
White sandstone	1	0	—	
Gravel and large stones (dipping at 21°)	33	0	—	
Conglomerate	8	6	—	
White sandstone	7	0	—	
Gravel with patches of white sandstone (dipping at 30°)	20	0	—	
Conglomerate (dipping at 35°)	30	0	219	0
White sandstone	1	6	—	

	Thickness. Ft.	In.	Depth. Ft.	In.
Red marl ...	3	0	—	
White sandstone	17	6	241	
Borehole commenced at 237 *ft.*				
Red marl ...	10	0	251	0

No. 2, *Moor's Gorse.*—Shaft and Boring close to the railway, two miles N.E. of Hednesford. Heading, 700 yards long, from base of shaft. Average daily yield in 1915, 1,400,560 gallons.[1] Six-inch Map, Staffs. 45 S.E.

Lat. 52° 43′ 58″. Long. 1° 57′ 50″ W.

Made in 1876 by Messrs. J. Aird & Sons; communicated by Mr. H. Ashton Hill.

Top 429 ft. above Ordnance Datum.

	Thickness. Ft.	In.	Depth. Ft.	In.
Bunter Pebble-Beds :—				
Surface soil	0	9	0	9
Conglomerate, getting harder towards bottom	93	0	—	
Light grey conglomerate and conglomeratic sandstone	5	0	99	6
Hard light sandstone; thin girdles (much water)	7	0	106	6
Borehole commenced at 104 *feet* 0½ *inch.*				
Mild light sandstone; pebbles. Fissure with large feeder of water at 124 ft. 10 in.	18	4	124	10
Mild light sandstone, thin girdles (water)	7	0	—	
Loose ground like gravel (water)	10	0	—	
Strong light sandstone (water)	9	6	152	0
Coal Measures :—				
Soft light grey shale	0	9	152	9

The thicknesses and depths are given as supplied.

No. 3, *Huntington.*—Shaft and Boring about two miles N. of Cannock. Average daily yield in 1915, 454,303 gallons.[2] Six-inch Map, Staffs. 51 N.W.

Lat. 52° 42′ 49″. Long. 2° 2′ 26″ W.

Published *Rept. Brit. Assoc.* for 1887, p. 367.

Top 528 ft. above Ordnance Datum.

	Thickness. Ft.	In.	Depth. Ft.	In.
Bunter Pebble-Beds :—				
Red marl ...	9	0	—	
Grey sandstone ...	31	0	—	
Slightly micaceous sandstone ...	16	0	—	
Rather coarse grey micaceous sandstone with pebbles ...	38	6	—	
Quartzite pebbles	0	6	—	
Conglomerate, loose	15	0	—	
Massive compact conglomerate...	3	0	—	
Fine grained sandstone, few pebbles ...	7	0	—	
Micaceous purple and grey-striped sandstone, few pebbles	9	0	—	
Fine-grained grey sandstone ...	15	0	—	
Purple and grey fine-grained sandstone	9	0	—	
Massive conglomerate, with vein quartz-pebbles ...	30	0	183	0
Boring commenced.				
Hard conglomerate	3	0	—	
Conglomerate with partings (water) ...	8	0	—	
Light grey sandstone with pebbles and water	6	0	—	
Hard conglomerate	1	0	—	

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[1] 'Return as to Water Undertakings in England and Wales,' *Local Gov. Board*, 1915, p. 216.

[2] *Ibid.*

	Thickness. Ft.	In.	Depth. Ft.	In.
Bunter Pebble Beds:—cont.				
Mild grey sandstone (water)	6	3	—	
Hard conglomerate	0	9	—	
Mild grey sandstone (water)	6	0	—	
Hard grey sandstone, sop partings, pebbles ...	5	6	—	
Hard conglomerate, sandstone partings ...	7	0	—	
Hard sandstone and conglomerate (water) ...	8	2	234	8
Coal Measures:—				
Soft red and grey shale	1	3	—	
Soft grey shale	1	5	—	
Soft shale...	0	7	—	
Soft grey and red shale (little coal)	3	7	—	
Soft light-grey shale	6	8	—	
Coal	1	7	—	
Soft grey shale	2	6	—	
Black shale	1	6	253	3
			[253	9]

No. 4, Maple Brook.—Boring by side of the small stream near four cross-roads, 3½ miles N.W. of Lichfield. Six-inch Map, Staffs. 52 S.W.

Lat. 52° 41′ 40″. Long. 1° 54′ 30″ W.

Made in 1910 by Messrs. A. C. Potter & Company, and communicated by Mr. H. Ashton Hill.

Top about 475 ft. above Ordnance Datum.

		Thickness. Ft.	In.	Depth. Ft.	In.
[Superficial]	Surface soil	1	6		
	Soft loamy gravel	2	6	—	
	Red marl and pebbles	6	6	—	
	Running gravel	1	6	12	0
[Lower Keuper]	Red marl	5	0	—	
	Grey sandstone	1	0	—	
	Red sandy marl	4	0	—	
	Grey sandstone	0	10	—	
	Red sandstone	1	0	—	
	Grey sandstone	1	2	—	
	Red sandstone and marl	1	2	—	
	Red and grey mottled sandstone ...	2	0	—	
	Red sandstone, very hard	1	10	—	
	Grey sandstone, very hard	1	6	—	
	Yellow sandstone	0	3	—	
	Red mottled loamy sandstone	7	3	—	
	Hard grey sandstone	2	0	—	
	Grey sandstone	1	6	—	
	Red sandstone	40	6	—	
	Red sandstone with thin layer of gravel	9	0	—	
	Red sandstone (36 in. boring down to 115 feet)	26	0	118	0
	Red marl	2	0	—	
	Sandstone and pebbles	9	0	—	
	Red and mottled sandstone	3	0	—	
	Mottled sandstone and marl	2	0	—	
	Mottled sandstone	13	0	—	
	Red sandstone	3	0	—	
	Marl, mottled sandstone	10	0	—	
	Mottled sandstone	1	0	—	
	Red sandstone	13	0	—	
	Catbrain, conglomerate	2	0	—	
	Mottled sandstone	11	0	—	
	Marl	2	0	—	
	Sandstone	11	0	200	0

		Thickness. Ft.	In.	Depth. Ft.	In.
[Upper Mottled Sandstone]	Sandstone and marl	15	0	—	
	Very soft sandstone	12	0	—	
	Red sandstone and marl	8	0	—	
	Soft red sandstone	7	0	—	
	Red sandstone	3	0	—	
	Sandstone	8	0	—	
	Soft sandstone	5	0	—	
	Soft sandstone and marl	22	0	—	
	Red sandstone and marl	20	0	300	0
[Pebble Beds]	Soft red and grey sandstone	84	0	—	
	Red and grey sandstone with thin layers of marl	30	0	—	
	Red and grey sandstone	114	0	—	
	Red and grey sandstone with a few pebbles	97	0	—	
	Red and grey sandstone and conglomerate (large pebbles)	3	0	—	
	Conglomerate	14	0	—	
	Conglomerate	2	0	644	6

No. 5, *Fradley.*—Close to the railway, three miles N.E. of Lichfield. Average daily yield in 1915, 1,026,808 gallons.[1] Shaft to 172 ft.; 7½ in. boring below. Six-inch Map, Staffs. 53 N.W. (Derby. 62 N.W.)

Lat. 52° 42′ 20″. Long. 1° 45′ 40″ W.

Made and communicated by Mr. H. Ashton Hill.

Top 210 ft. above Ordnance Datum.

		Thickness. Ft.	In.	Depth. Ft.	In.
Superficial	Soil	1	6	—	
	Gravel	7	0	8	6
Keuper Marl	Red clay	4	8	—	
	Red clay and marl	13	5	—	
	Red clay and gypsum	68	0	—	
	Red and grey marls	30	2	—	
	Red and grey marls and gypsum	4	4	—	
	Gypsum	2	0	—	
	Red and grey marls	2	4	—	
	Grey marls	0	7	—	
	Red marls	0	5	—	
	Grey marls	0	3	—	
	Red marls	0	1	—	
	Grey marls	0	3	—	
	Red marls	0	8½	—	
	Grey marls	1	8	—	
	Red and grey marls in layers	1	1	—	
	Gypsum (working water-level)	0	2	137	7½
	Red marl	1	3	—	
	Gypsum mottled with grey marl	0	3	—	
	Red marl	2	8	—	
	Grey marl	0	4	—	
	Red marl	0	2½	—	
	Grey marl	0	2½	—	
	Red marl mottled with grey	13	11	—	
	Grey marl	0	3	—	
	Red marl	0	5	—	
	Grey marl	0	3	—	
	Red and grey marl in layers	1	7	—	
	Red marl	2	6½	—	
	Grey marl and gypsum	0	5	—	
	Red marl	2	8	—	
	Grey marl	14	0	178	8

The thicknesses and depths are given as supplied.

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[1] 'Return as to Water Undertakings in England and Wales,' *Local Gov. Board*, 1915, p. 216.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Keuper Sandstone	Strong red sandstone (water) ...	8	6	—	
	Red sandstone, dark red partings (water)	72	6	—	
	Honeycombed red and light sandstone with hard girdles (much water)	20	0	—	
	Strong red sandstone (much water)	29	8	—	
	Red sandstone, brown shale (water)	27	10	—	
	Honeycombed sandstone with hard girdles (much water)	89	6	426	8
? Bunter	Red sandstone, brown and light-red shaly partings (much water) ...	100	0	526	8

No. 6, *Trent Valley.*—Close to the intersection of the two railways, a mile E. of Lichfield. Average daily yield in 1915, 1,529,676 gallons.[1] Six-inch Map, Staffs. 52 S.E.

Lat. 52° 41′ 15″. Long. 1° 47′ 45″ W.

Made and communicated by Mr. H. Ashton Hill.

Top 245 ft. above Ordnance Datum.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Keuper Sandstone	Red sandstone	30	3	—	
	Marl	2	6	—	
	Red sandstone	7	3	—	
	Red marl	1	0	—	
	Red sandstone	3	0	—	
	Rough sandstone	5	6	—	
	Red marl	2	6	—	
	Loamy sandstone	8	0	—	
	Marl	6	6	—	
	Loamy sandstone	33	6	—	
	Red sandstone	99	0	—	
	Thin parting of marl	0	6	199	6
Doubtful	Red sandstone	21	6	221	0
Bunter	Conglomerate	17	6	—	
	Red sandstone	9	0	—	
	Conglomerate	85	6	—	
	Rough red sandstone	4	0	—	
	Conglomerate	29	6	—	
	Light red sandstone	2	6	—	
	Conglomerate	14	6	—	
	Red sandstone	1	0	—	
	Conglomerate	40	6	425	0
Doubtful	Red sandstone	3	0	—	
	Red sandstone with small pebbles	10	0	—	
	Red sandstone	11	0	449	0
Hamstead Beds ?	Grey sandstone	1	0	—	
	Red marl	50	0	500	0

No. 7, *Lichfield, or Sandfields.*—Close to the junction of the two railways, a mile S. of Lichfield. Shaft 71 ft. in Keuper Sandstone. Sump to galleries 4 miles long. Average daily yield in 1915, 2,885,363 gallons.[2] Six-inch map, Staffs. 58 N.E.

Lat. 52° 40′ 25″. Long. 1° 50′ 0″ W.

Top 355 ft. above Ordnance Datum.

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[1] 'Return as to Water Undertakings in England and Wales,' *Local Gov. Board*, 1915, p. 216.

[2] *Ibid.*

No. 8, *Pipe Hill.*—Between the canal and High Road, 2 miles S.W. of Lichfield. Average daily yield in 1915, 1,818,788 gallons.[1] Six-inch Map, Staffs. 58 N.W.

Lat. 52° 39′ 50″. Long. 1° 52′ 20″ W.

Communicated by Mr. H. Ashton Hill.

Top 355 ft. above Ordnance Datum.

	Thickness. Ft.	In.	Depth. Ft.	In.
Tapped water	6	0	—	
Water increased	6	0	12	0
Red sandstone with balls of red marl	6	0	—	
Red sandstone	3	0	—	
Red marl	10	0	—	
Red sandstone	15	0	—	
Loamy sandstone	32	0	—	
Red marl	6	0	—	
Loamy sandstone	16	0	—	
Marl	3	0	—	
Loamy sandstone	8	0	—	
Loamy sandstone with layers of red marl	4	0	—	
Loamy sandstone	4	0	—	
Loamy sandstone with layers of red marl	1	0	—	
Loamy sandstone	7	0	—	
Loamy sandstone with layers of red marl	12	0	—	
Red sandstone	5	6	—	
Grey sandstone	3	6	—	
Red sandstone with layers of red marl	5	0	—	
Red sandstone	42	0	195	0
Red sandstone with small pebbles	63	0	—	
Conglomerate	65	0	—	
Red sandstone with beds of marl	77	0	—	
Conglomerate	14	0	—	
Red sandstone and marl	88	0	502	0
Red marl[2] very sticky	20	0	—	
Red marl	25	0	547	0

No. 9, *Shenstone.*—West side of the railway, a little W. of the village. Average daily yield in 1915, 1,130,645 gallons.[3] Six-inch Map, Staffs. 58 S.W.

Lat. 52° 38′ 26″. Long. 1° 50′ 36″ W.

Made by the Company in 1891; communicated by Mr. H. Ashton Hill.

Top 313 ft. above Ordnance Datum.

	Thickness. Ft.	In.	Depth. Ft.	In.
Soil	1	0	—	
Sand and gravel	3	6	4	6
Red sandstone	7	6	—	
Conglomerate	76	0	—	
Red sandstone	21	3	—	
Red marl	0	9	—	
Red sandstone	7	0	—	

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[1] 'Return as to Water Undertakings in England and Wales,' *Local Gov. Board*, 1915, p. 216.

[2] This and the bed below are probably Hamstead Beds, and the beds immediately above may also be of this age. The Conglomerate is either Pebble Beds or the Hopwas Conglomerate; probably the former.

[3] 'Return as to Water Undertakings in England and Wales,' *Local Gov. Board*, 1915, p. 216.

	Thickness. Ft. In.	Depth. Ft. In.
Borehole (18 *in.*) *commenced* 117 *ft.*		
Conglomerate, hard	18 0	—
Conglomerate	7 0	—
Sand and gravel	3 0	—
Conglomerate and marl, fine	10 0	—
Sandstone, coarse	4 0	—
Conglomerate, fine	12 0	—
Pebbly marl	8 0	177 0
Sandstone	3 6	—
Red marl	2 0	—
Red and green marl	3 0	—
Red sandstone	1 6	—
Dark brown sandstone	9 0	—
Red marl	8 0	—
Red and green marl	4 0	—
Red marl	6 9	214 9

The beds below 177 ft. are certainly Carboniferous; a small portion of the overlying beds may also be of this age.

No. 10, *Bourne Vale, or Aldridge.*—About 1 mile S.E. of Aldridge. Average daily yield in 1915, 1,504,207 gallons.[1] Six-inch Map, Staffs. 64 N.W.

Lat. 52° 35′ 45″. Long. 1° 53′ 25″ W.

Made by the Company and communicated by Mr. H. Ashton Hill.

Top 425 ft. above Ordnance Datum.

		Thickness. Ft. In.	Depth. Ft. In.
	Surface soil	0 6	0 6
[Bunter]	Loose sand and gravel	49 6	—
	Red marl	5 0	—
	Red sandstone	5 6	—
	Loose sand and gravel	5 0	—
	Soft red sandstone	2 6	—
	Strong red sandstone	15 0	—
	Gravel	13 0	96 0
[Hopwas Breccia ?]	Red sandstone and pebbles ...	21 0	—
	Red sandstone	6 0	123 0
[Hamstead Group]	Red marl	0 6	—
	Red sandstone	10 6	—
	Red marl mixed with red sandstone	33 0	—
	Red marl.	6 0	—
	Sandstone	18 0	—
	Red marl	19 0	—
	Red marl mixed with red sandstone	5 0	—
	Loamy sandstone	8 6	—
	Red marl	3 6	—
	White sandstone	0 6	—
	Red marl, thin bands of white sandstone	13 6	—
	Blue clay with red marl	0 6	—
	Red marl	2 6	244 0

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[1] 'Return as to Water Undertakings in England and Wales,' *Local Gov. Board*, 1915, p. 216.

TAMWORTH AND TAMWORTH RURAL.

No. 1, *Hopwas Well.*—North side of Lichfield Road, 700 yards W. of the canal at Hopwas. Six-inch Map, Staffs. 59 S.W.

Lat. 52° 38′ 30″. Long. 1° 44′ 44″ W.

Made in 1879 under the superintendence of Mr. H. J. Martin, M.I.C.E., and described by him in *Rep. Brit. Assoc.* for 1882, p. 222.

Top 306 ft. above Ordnance Datum.

	Thickness. Ft.	In.	Depth. Ft.	In.
Soil, sand and gravel	16	6	16	6
Red marl, with layers of sandstone	15	11	—	
Hard conglomerate-rock	5	7	—	
Argillaceous marl-rock	39	11	—	
Fissured sandstone	13	9	—	
Argillaceous marl-rock	5	0	—	
Light fissured sandstone-rock	30	4	—	
Red marl with layers of blue stone, and balls of marl of the same colour with dark spot in centre, called fish-eyed marl	41	0	168	0

The soil, sand and gravel are debris from the Bunter Pebble Beds; the rest of the section is in Hamstead Beds.

No. 2, *Bolehall Boring.*—About 50 yards E. of the Midland Railway Viaduct, on the south side of Tamworth. In Keele Beds (see p. 224). Six-inch Map, Warwick. 2 S.E.

Lat. 52° 37′ 48″. Long. 1° 41′ 5″ W.

Made in 1875 for the Tamworth Board, and communicated by Mr. H. J. Clarson, Town Surveyor.

Top about 210 ft. above Ordnance Datum.

	Thickness. Ft.	In.	Depth. Ft.	In.
Made ground	3	0	3	0
Yellow sandstone rock	4	0	—	
Red sandstone rock	3	4	—	
,, marl	0	4	—	
,, sandstone-rock	2	0	—	
,, marl-parting	0	2	—	
,, sandstone-rock	4	8	—	
,, marl-parting	0	2	—	
,, sandstone-rock	17	0	—	
,, marl-parting	0	2	—	
,, pebble-rock [pellet-sandstone]	4	2	—	
,, marl-parting	0	2	—	
,, pebble-rock [pellet-sandstone]	14	10	—	
,, marl-parting	0	2	—	
,, pebble-rock	8	8	—	
,, marl-parting	0	3	—	
,, sandstone	8	11	—	
,, marl-parting	0	2	—	
,, rock-marl	0	9	—	
,, rock	0	9	—	
,, strong mottled ground	5	10	—	
,, rock	4	6	—	
,, rock-marl	3	9	—	
,, pebble-[pellet] rock	6	5	—	
,, hard rock	4	0	—	

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Red rock		2	10	—	
,, rock (very hard)		3	6	—	
,, rock		6	0	—	
,, rock (very hard)		9	6	—	
,, parting	Water-bearing strata.	0	4	—	
,, rock		8	4	—	
,, hard rock		0	8	—	
,, marl and marl-rock		8	6	—	
Light sandstone		21	6	159	4
Hard red rock		2	6	—	
Parting		0	2	—	
Hard red rock		1	4	—	
Rock-marl		2	0	—	
Light-red rock		1	8	—	
Bright-red marl		3	4	—	
Rock and rock-marl		8	6	—	
Red rock		1	0	—	
,, marl		11	0	—	
,, rock		4	2	195	0

No. 3, *Moor Farm Boring.*—On the River-gravel of the Anker, one mile N.E. of Tamworth (see p. 224). Six-inch Map, Warwick. 2 S.E.

Lat. 52° 38′ 35″. Long. 1° 40′ 20″ W.

Made for the Tamworth Board in 1875, and communicated by Mr. H. J. Clarson, Town Surveyor.

Top nearly 200 ft. above Ordnance Datum.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
[River Deposit.]	Soil	1	0	—	
	Sand and gravel	6	6	—	
	Clay	2	0	9	6
[Keuper Sandstone.]	Strong grey rock	10	6	—	
	Clay	0	3	—	
	Strong grey rock	2	6	—	
	Soft grey rock	3	3	—	
	Marl	0	3	—	
	Strong red stone	3	2	—	
	Soft red stone	4	0	—	
	Clay	0	4	—	
	Strong grey rock	4	3	—	
	Clay	0	3	—	
	Strong red stone	4	6	—	
	Soft red stone	7	0	—	
	Clay	0	3	—	
	Strong red stone	5	0	—	
	Soft red stone	7	0	—	
	Clay	0	3	—	
	Strong red rock	19	9	82	0

No. 4, *Coton Boring.*—About a mile and a half W.N.W. of Tamworth, opposite the Hall, Coton (see p. 225). Six-inch Map, Staffs. 59 S.W.

Lat. 52° 38′ 40″. Long. 1° 43′ 20″ W.

Made for the Tamworth Board in 1878, and communicated by Mr. H. J. Clarson, Surveyor.

About 185 ft. above Ordnance Datum.

		Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
[River Deposit.]	Soil and gravel	4	0	—	
	Sand and gravel (wet)	12	0	—	
	Light red sand	13	0	—	
	Sharp sand and water	4	0	—	
	Gravelly clay	3	6	—	
	Strong loamy red sand	1	6	—	
	Strong gravel	2	0	40	0
[Keuper Marl.]	Fresh sandstone	3	0	—	
	Loamy sandstone	6	0	—	
	Strong clay	9	0	—	
	Strong marl with gypsum	6	0	—	
	Blue skerry or marl in layers ...	6	0	—	
	,, ,, ...	2	4	—	
	Red marl with layers of gypsum ...	13	9	—	
	Very hard rock containing much lime	2	2	—	
	Marl containing gypsum	7	6	—	
	Red and mixed rock	3	0	—	
	Light red rock	0	7	—	
	Red marl parting	0	6	—	
	Hard grizzly rock	1	0	—	
	Stony marl with gypsum	4	0	—	
	Mottled rock	1	9	—	
	Hard light rock	1	6	—	
	Mottled marl with gypsum ...	12	4	120	5

No. 5, Hurley, Shaft and Boring.—Six-inch Map, Warwick. 5 S.E.

Lat. 52° 34′ 14″. Long. 1° 38′ 0″ W.

Made in 1892 for the Tamworth Rural Council, and communicated by Mr. H. J. Clarson, Surveyor. (See p. 225).

Top about 330 ft. above Ordnance Datum.

	Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Mainly red marl (the sunk well)	26	0	26	0
Grey sandstone	8	5	—	
Red marl	7	0	—	
Marl and sandstone	3	7	—	
Red marl	23	10	—	
Grey rock	9	0	—	
Red sandstone rock	3	0	—	
Hard red rock	3	0	—	
Red marl and stone [sandstone]	23	0	—	
Blue marl	5	0	—	
Red marl and stone	30	2	142	0

The whole of these beds belong to the Keele Group.

ATHERSTONE DISTRICT COUNCIL.

Warton Shaft and Boring.—Situated on the east side of the road, about a mile east-by-north of Polesworth Church. One-inch Map, (N.S.) 155. Six-inch Warwick. 3 S.W.

Lat. 52° 37′ 15″. Long. 1° 35′ 10″ W.

Shaft for 13 ft., with boring 20 inches diameter to 300 ft. Lined with steel tubes 18 in. internal diameter to 75¼ ft., and with similar tubes from 155½ to 212½ to keep out loose sand.

Water-level 41 ft. down; falls to 63 on full pumping, rising 18 ft. in 25 minutes when pumping ceases and to normal level in 24 hours. Yield, after prolonged test, 240,000 gallons a day, or 10,000 an hour.

Made by the New England Boring Co., in 1913; communicated by Mr. H. J. Coleby, Engineer and Surveyor to the Council.

Top 262 ft. above Ordnance Datum.

		Thickness. Ft.	Depth. Ft.
Keuper Sandstone	Red marl	21½	—
	Grey sandstone with pellets of green marl	15½	—
	Red marl	6	—
	Grey sandstone	14	—
	Red marl	1½	—
	Grey sandstone with fine breccia... ...	5½	64
Bunter Sandstone (some Pebble-Beds)	Red marl	3	—
	Sandstone with red and green marl-partings	6	—
	Reddish brown sandstone	4	—
	Reddish brown sandstone with green marl-partings	6½	—
	Grey sandstone	12½	—
	Red and brown sandstone	12	—
	Grey sandstone	1	—
	Red shaly marl	1	—
	Brown and yellow variegated sandstone	16	—
	Red shaly marl	4	—
	Red sandstone	7	—
	Brown and grey variegated sandstone ...	9	—
	Red and green shaly marls	6	—
	Loose pebbles	1	—
	Grey sandstone	2	—
	Hard conglomerate	2	—
	Grey sandstone	3	—
	Friable white sandstone with some pebbles and with bands of brown sandstone of closer texture	30	—
	Brown sandstone	4	—
	Red shaly marl	4	—
	Reddish brown sandstone	1	—
	Red and green shaly marls	5	—
	Brown and yellow variegated sandstone	96	300

This boring has been made since the Memoir on Sheet 155 N.S. was published. It is of interest, apart from the good yield of water, in proving the existence of a pre-Triassic valley, occupied by Bunter deposits. At the north end of the Warwickshire coalfield there is no Bunter. The Lullington Boring (p. 154) probably lies in the continuation of this valley, the existence of which will have to be taken into account in efforts to reach coal within it.

APPENDIX II.

LIST OF PRINCIPAL WORKS ON THE GEOLOGY OF THE DISTRICT.

PUBLICATIONS OF THE GEOLOGICAL SURVEY.

Maps.

1852. Old Series One-inch Geological Map, Sheet 62 N.W. (revised 1859).

1852. Old Series One-inch Geological Map, Sheet 62 S.W. (revised 1855, 1858, 1885).

1855. Old Series One-inch Geological Map, Sheet 62 S.E. (revised 1886).

1856. Old Series One-inch Geological Map, Sheet 62 N.E. (revised 1859).

Sections.

1853. Vertical Sections; the South Staffordshire Coalfield, Sheets 16 and 18; the Warwickshire Coalfield, Sheet 21.

1853-86. Horizontal Sections, Sheets 23, 24, 25, 45, 48, 49, 58, 83.

Memoirs.

1853. Records of the School of Mines, vol. 1, part II. On the Geology of the South Staffordshire Coal Field, by J. B. Jukes, pp. 149-335, with Map and Sections. Note on the Stigmaria Beds of the South Staffordshire Coal Field, by Sir H. De la Beche, pp. 336-339. Note on the Mode of Working the Coal and Ironstone of South Staffordshire, by W. W. Smyth. Note on Coal Raised and Iron Made at Present (December, 1852), in South Staffordshire, by R. Hunt, pp. 342-346.

1855-1881. Mineral Statistics of the United Kingdom . . . . for the years 1853-1880.

1858. Iron Ores of Great Britain, part II. (South Staffordshire).

1859. Geology of the South Staffordshire Coal Field, Ed. 2, by J. B. Jukes (*out of print*).

1859. Geology of the Warwickshire Coal Field, by H. H. Howell.

1869. Triassic and Permian Rocks of the Midland Counties, by E. Hull.

1900. Geology of the Country between Atherstone and Charnwood Forest, by C. Fox-Strangways, with Notes on Charnwood Forest, by W. W. Watts.

1911-17. Summary of Progress of the Geological Survey, for the years 1910-16.

List of Books, Papers, &c.

1773. Withering, W.—Experiments on the different kinds of Marl found in Staffordshire. *Phil. Trans.*, vol. lxiii, part 1, p. 161.

1810. Farey, J.—A list of about 500 Collieries in and near to Derbyshire, *Phil. Mag.*, vol. xxxv, pp. 431-438.

1816. Aikin, A.—Some observations on a bed of Trap occurring in the Colliery of Birch Hill, near Walsall, in Staffordshire. *Trans. Geol. Soc.*, ser. 1, vol. iii, p. 251.

1818. Finch, J.—An account of some Basaltic Columns at Pouck Hill, Staffordshire, with Prehnite, Zeolite and Barytes. *Ann. Phil.*, vol. xii, pp. 167-169.

1821. Yates, Rev. J.—Account of a variety of Argillaceous Limestone found in connection with the iron ore of Staffordshire. *Trans. Geol. Soc.*, ser. 1, vol. v, pp. 375-378.

1829. Jukes, F.—Notice of some Fragments of *Orthoceras Annularis* and *Striata* found in the Barr Limestone in Warwickshire; with a note by J. de C. Sowerby. *Mag. Nat. Hist.*, vol. ii, pp. 231-233.

1839. Murchison, Sir R. I.—The Silurian System. 4to. *London.*

1847. Buckman, J.—On the Age of the Silurian Limestone of Hay Head, near Barr Beacon, in Staffordshire. *Rep. Brit. Assoc.* for 1846, p. 61.

1847. Buckman, J.—On the Discovery of a New Species of Hypanthocrinite in the Upper Silurian strata. *Rep. Brit. Assoc.* for 1846, pp. 61-62.

1847. Davidson, T.—Observations on some of the Wenlock Limestone Brachiopoda, etc. *London Geol. Journ.*, p. 52.

1847. Lewis, W. A.—On a New Species of Hypanthocrinites from the Wenlock Shale of Walsall. *London Geol. Journ.*, p. 99.

1848. Buckman, J.—Notice of the Discovery of some new Cystideans from the Wenlock Shale near Walsall, *Rep. Brit. Assoc.* for 1847 (sectn. B, 67).

1853. Jukes, J. B.—On the Occurrence of Caradoc Sandstone at Great Barr, South Staffordshire. *Quart. Journ. Geol. Soc.*, vol. ix, p. 179.

1860. Bateman, J. F.—On an Artesian Well in the New Red Sandstone at the Wolverhampton Waterworks. *Rep. Brit. Assoc.* for 1859, pp. 229-230.

1860. Lister, Rev. W.— On some Reptilian Footprints in the New Red Sandstone north of Wolverhampton. *Geologist*, vol. iii, pp. 308-309.

1861. **Lister, Rev. W.**—On some Reptilian Footprints from the New Red Sandstone north of Wolverhampton, *Rep. Brit. Assoc.* for 1860, p. 87.

1862. **Beckett, H.**—Inaugural Address. *Proc. Dudley and Mid. Geol. and Sci. Soc.*, vol. i, pp. 3-12.

1865. **Brown, E.**—The Geology and the Mineral Waters of Burton-on-Trent (Read to *Brit. Assoc.*). 8vo. Burton.

1866. **Jones, J.**—Notes on the Geology of the Midland Counties. 8vo. Birmingham and London. (Simpkin, Marshall, and Co.); 24 pp.

1867. **Johnson, H.**—On the Extension and probable Duration of the South Staffordshire Coal Field (Read to *Brit. Assoc.*). *Geol.* and *Nat. Hist. Repertory*, vol. i, pp. 168-169.

1867. **Murchison, Sir R. I.**—On the parts of England and Wales in which Coal may and may not be looked for beyond the known Coal Fields. *Rep. Brit. Assoc.* for 1866, pp. 57-63.

1868. **Johnson, H.**—On the Green Rocks and Basalt of the South Stafford Coal Field. *Trans. Manchester Geol. Soc.*, vol. v, pp. 83-91.

1869? **Molyneux, W.**—Burton-on-Trent: its History, its Waters and its Breweries. Map of the town with geological section, also section in Bretby Colliery Railway. *Geology*, pp. 147-213. 8vo. n.d. London and Burton.

1870. **Allport, S.**—On the Basaltic Rocks of the Midland Coal Fields. *Geol. Mag.* for 1870, pp. 159-162, 431-435.

1870. **Hull, E.**—On the Extension of the Coal Fields beneath the newer formations of England, etc. *Rep. Brit. Assoc.* for 1870, Sections, pp. 74, 75. Printed separately under different title. 8vo. London, 1870.

1871. Report of the Commissioners appointed to enquire into the several matters relating to Coal in the United Kingdom. 3 vols. Folio. London.

1871. **Addenbrooke, G.**, and **Parton, T.**—Iron Ores Committee. *South Staffordshire Journ. Iron and Steel Inst.*, vol. ii, pp. 6-26.

1872. **Woodward, C. J.**—Report of the Progress made in mapping the Boulders during the year 1869. *Proc. Birmingham Nat. Hist.* and *Micr. Soc.*, for 1870, No. 2, pp. 57-58.

1873. **Bonney, Rev. T. G.**—On the occurrence of a Quartzite Boulder in a coal seam in South Staffordshire. *Geol. Mag.* for 1873, p. 289.

1873. **Molyneux, W.**—On the occurrence of Copper and Lead ores in the Bunter Conglomerates of Cannock Chase. *Rep. Brit. Assoc.* for 1872; sect., pp. 116-117. See also *Geol. Mag.* for 1873, p. 16.

1874. Allport, S.—On the Microscopic Structure and Composition of British Carboniferous Dolerites. *Quart. Journ. Geol. Soc.*, vol. xxx, pp. 529-567. Plate.

1874-87. Crosskey, Rev. W. H.—Reports of the Committee for recording Erratic Blocks, etc. *Rep. Brit. Assoc.*

1875. Molyneux, W.—A visit to Cannock Chase. *Coll. Guardian*, vol. xxix, pp. 773-774.

1876. Molyneux, W.—The Old River Courses and the Recent Floods of the Trent, etc. 8vo. R. R. Bellamy, Burton-on-Trent. 19 pp.

1877. Blakemore, W.—The Faults of the South Staffordshire Coal Field. *Trans. South Staff. Inst. Min. Eng.*, New Series. vol. iii, pp. 52-57, 92-97, 108-112, 126-132.

1877. Molyneux, W.—The Bunter Conglomerate of Cannock Chase. *Proc. Dudley Mid. Geol. Soc.*, vol. iii, No. 5, pp. 139-149.

1877. Oliver, J. W.—Railway Cutting at Daw End, near Walsall. *Proc. Dudley Mid. Geol. Soc.*, vol. iii, pp. 111-112. Section.

1878. Grayston, F. A.—Correlation of the Leicester, Warwickshire, South Staffordshire and Shropshire Coal Fields. (*Tamworth Nat. Hist. Soc.*), *Mid Naturalist*, vol. i, p. 112.

1878. Harrison, W. J.—A Scheme for the Examination of the Glacial Deposits of the Midland Counties of England. *Ibid.*, pp. 242-245, and *Proc. Dudley Mid. Geol. Soc.*, vol. iv, pp. 46-49; pub. 1880.

1879. Beale, C.—Examination of Drift, Railway Cutting, near Walsall. *Mid. Naturalist*, vol. ii, pp. 226-227.

1879. Allport, S.—On the Diorites of the Warwickshire Coal Field. *Quart. Journ. Geol. Soc.*, vol. xxxv, pp. 637-642.

1879. Clarke, J. E.—On the Triassic Boulder, Pebble and Clay Beds at Sutton Coldfield, near Birmingham. *Proc. York. Geol. Soc.*, n.s., vol. vii, pt. i, pp. 66-72.

1879. Twigg, G. H.—Examination of Drift Railway Cutting, near Walsall. *Mid. Naturalist*, vol. ii, pp. 201-202.

1880. Mackintosh, D.—On the Correlation of the Drift Deposits of the North-west of England with those of the Midland and Eastern Counties. *Quart. Journ. Geol. Soc.*, vol. xxxvi, pp. 178-188.

1881. Brodie, Rev. P. B.—On certain Quartzite and Sandstone Fossiliferous Pebbles in the Drift in Warwickshire, and their probable Identity . . . with Lower Silurian Pebbles . . . in the Trias at Budleigh Salterton, Devonshire. *Quart. Journ. Geol. Soc.*, vol. xxxvii, pp. 430-435.

1882. **Harrison**, W. J.—On the Quartzite Pebbles contained in the Drift and in the Triassic Strata of England, and on their derivation from an Ancient Land Barrier in Central England. *Proc. Birmingham Phil. Soc.*, vol. iii, pp. 157-202.

1882. **Lapworth**, Prof. C.—On the Discovery of Cambrian Rocks in the Neighbourhood of Birmingham. *Proc. Birmingham Phil. Soc.*, vol. iii, pp. 234-238; *Geol. Mag.* for 1882, pp. 563-566.

1883. **De Rance**, C. E.—Eighth Report of the Committee . . on the Circulation of Underground Waters, &c. *Rep. Brit. Assoc.* for 1882, pp. 213-239.

1885. **Harrison**, W. J.—On the Pre-Carboniferous Floor of the Midlands. *Mid. Naturalist*, vol. viii, pp. 38-40; 69-73; 100-104; 131-135; 163-167; 194-198.

1885. **Whitaker**, W.—List of Works on the Geology, Mineralogy, and Palæontology of Staffordshire, Worcestershire and Warwickshire. *Rep. Brit. Assoc.* for 1885, pp. 780-813.

1886. **Strahan**, A.—On the Rocks surrounding the Warwickshire Coalfield and on the Base of the Coal Measures. *Geol. Mag.* for 1886, pp. 540-557. *Rep. Brit. Assoc.* for 1886, p. 624.

1886. **Aulton**, A. D.—Excavations at Walsall. *Mid. Nat.*, vol. ix, pp. 322-323.

1886. **Deeley**, R. M.—The Pleistocene Succession in the Trent Basin. *Quart. Journ. Geol. Soc.*, vol. xlii, pp. 437-480. Abstract in *Geol. Mag.* for 1886, pp. 284-285.

1886. **Harrison**, W. J.—On the Discovery of Rocks of Cambrian Age at Dosthill in Warwickshire. *Mid. Nat.*, vol. ix, pp. 261-263.

1886. **Lapworth**, **Prof.** C.—On the Sequence and Systematic Position of the Cambrian Rocks of Nuneaton. *Geol. Mag.* for 1886, pp. 319-322.

1886. **Rutley**, F.—The Igneous Rocks in the Neighbourhood of Warwickshire Coalfield. *Ibid.*, pp. 557-565.

1887. **Lapworth**, **Prof.** C.—On the Geology of the Birmingham District. *Rep. Brit. Assoc.* for 1886, Sections, p. 621.

1887. **Crosskey**, **Rev.** W. H.—On the Glacial Phenomena of the Midland District (Charnwood Erratics). *Rep. Brit. Assoc.*, pp. 224-226.

1887. **Tuckwell**, **Rev.** W.—On the Glacial Erratics of Leicester and Warwickshire. (Dispersal of Mount Sorrel Granite into Warwickshire). *Ibid.*, p. 627.

1888. **Timmins, A.**—On the Occurrence of Copper in the Bunter Conglomerate of Huntington, Staffordshire. *Proc. Liverpool Geol. Soc.*, vol. v (1884-1888), pp. 256-257.

1890. **Gilbert, C. J.**—The Geology of Sutton Coldfield. (Read before the Vesey Club and privately printed).

1890. **Landon, J.**—The Barr Beacon Beds. *Proc. Birm. Phil. Soc.*, vol. vii, pp. 113-126.

1892. **Sopwith, A.**—The Northern part of the South Staffordshire Coalfield. *Trans. Fed. Inst. Min. Eng.*, vol. iii, pt. i, pp. 50-61. Map.

1892. **Reade, T. M.**—The Trias of Cannock Chase. *Proc. Liv. Geol. Soc.*, vol. vi, pp. 418-438.

1895. **Cantrill, T. C.**—On the Occurrence of Spirorbis-limestones and thin Coals in the so-called Permian Rocks of Wyre Forest; with Considerations as to the Systematic Position of the 'Permians' of Salopian Type. *Quart. Journ. Geol. Soc.*, vol. li, pp. 528-548.

1895. **Bonney, Prof. T. G.**—A Comparison of the Pebbles in the Trias of Budleigh Salterton and of Cannock Chase. *Geol. Mag.* for 1895, pp. 75-79. *Rep. Brit. Assoc.* for 1894, p. 655.

1895. **Harrison, W. J.**—Bibliography of Midland Glaciology. *Proc. Birm. Nat. Hist. Soc.*, vol. ix, pt. ii, and 8vo. Birmingham.

1895. **Reade, T. M.**—Pitted Pebbles in the Bunter Conglomerate of Cannock Chase. *Geol. Mag.* for 1895, pp. 341-345.

1895. **Landon, J.**—A section of Bunter Conglomerate. *Proc. Birm. Nat. Hist. and Phil. Soc.*, vol. i, No. 12, pp. 153-154.

1896. **De Rance, C. E.**—The Depth to Productive Coal Measures between the Warwickshire and Lancashire Coalfields. *Trans. Fed. Inst. Min. Eng.*, vol. x, pp. 244-258.

1897. **Mantle, H. G.**—The Glacial Boulders east of Cannock Chase. (Note on the Microscopic Characters of some, by W. S. Boulton). *Proc. Birm. Nat. Hist. and Phil. Soc.*, vol. x, pt. ii, pp. 33-80.

1897. **Kendrick, J. P.**—Sinking operations at Kingsbury Colliery. *Trans. Fed. Inst. Min. Eng.*, vol. xii, pp. 269-276.

1898. **Harrison, W. J.**—The Ancient Glaciers of the Midland Counties of England. *Proc. Geol. Assoc.*, vol. xv, pp. 400-408.

1898. **Lapworth, Prof. C.**—A Sketch of the Geology of the Birmingham District. *Ibid.*, pp. 313-416.

1898. Watts, Prof. W. W.—Report on the Long Excursion to the Birmingham District. *Ibid.*, pp. 417-428.

1900. Bonney, Prof. T. G.—The Bunter Pebble Beds of the Midlands and the Source of their Material. *Quart. Journ. Geol. Soc.*, vol. lvi, pp. 287-306.

1901. Gibson, W.—On the Characters of the Upper Coal-Measures of North Staffordshire, Denbighshire, South Staffordshire, and Nottinghamshire; and their Relations to the Productive Series. *Quart. Journ. Geol. Soc.*, vol. lvii, pp. 251-266.

1905. Final Report of the Royal Commission on Coal Supplies, part iii.

1906. Cockin, G. M.—On the Occurrence of Limestone of the Lower Carboniferous Series in the Cannock Chase Portion of the South Staffordshire Coalfield. *Quart. Journ. Geol. Soc.*, vol. lxii, pp. 523-539.

1908. Bonney, Prof. T. G.—On the Evidence for Desert Conditions in the British Trias. *Geol. Mag.* for 1908, p. 337.

1907. Grayston, F. A.—Presidential Address, Birmingham, 1906. *Trans. Fed. Inst. Min. Eng.*

1911. Cockin, G. M.—On the Carboniferous Limestone of Fair Oak, Cannock Chase Coalfield. *Trans. Fed. Inst. Min. Eng.*, vol. xli, 1911, pp. 323-336.

1912. King, W. W., and Lewis, W. J.—The Uppermost Silurian and Old Red Sandstone of South Staffordshire. *Geol. Mag.* for 1912, pp. 437-443 and 484-491.

1912. Hardaker, W. H.—The Permian Rocks of Hamstead. *Quart. Journ. Geol. Soc.*, vol. lxviii, pp. 639-683.

1912. Vernon, R. D.—On the Palæontology of the Warwickshire Coalfield. *Ib.*, pp. 587-638.

1913. Gibson, W.—A Boring for Coal at Claverley, near Bridgnorth, and its Bearing on the Extension Westward of the South Staffordshire Coalfield. *Trans. Fed. Inst. Min. Eng.*, vol. xlv, pp. 30-48.

1914. Clark, F. B.—Description of the Headings driven from the Aldridge Collieries to prove the Mines over the Main Eastern Boundary Fault. *Trans. Fed. Inst. Min. Eng.*, vol. xlvii, pp. 92-99.

1914. Forrest, N.—Description of the Proof of the Western Boundary Fault at Holly Bank Colliery. *Ib.*, pp. 360-384.

1916. Arber, E. A. N.—The structure of the South Staffordshire Coalfield, with Special Reference to the Concealed Areas and to the Neighbouring Fields. *Trans. Fed. Inst. Min. Eng.*, vol. lii, pp. 35-70.

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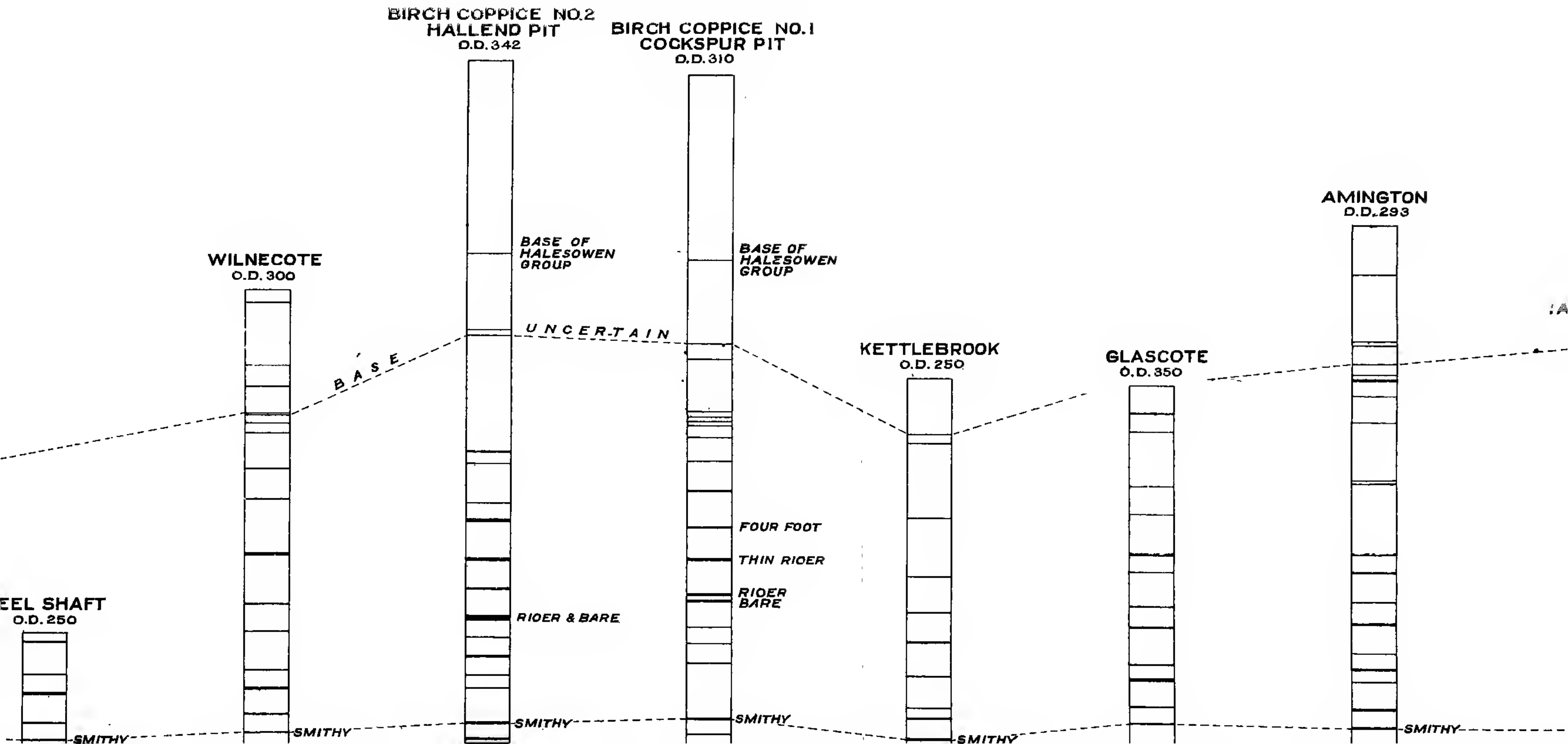
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